MOTOROLA Semiconductors

SMALL-SIGNAL TRANSISTOR DATA BOOK

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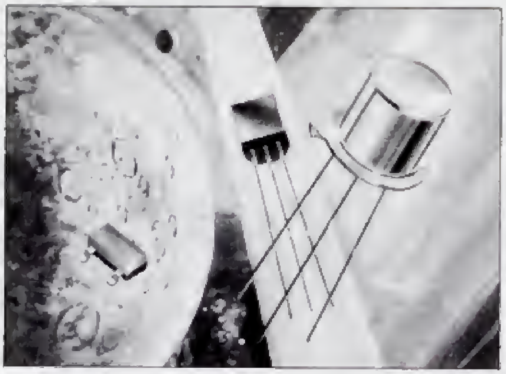

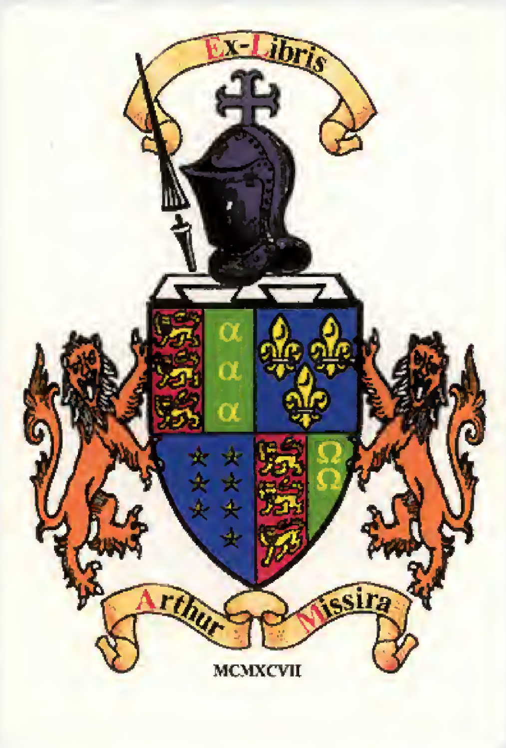
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SMALL-SIGNAL TRANSISTORS

This publication presents technical information for the several product families that comprise the Motorola small-signal transistor line. The families include both bipolar and field-effect transistors. These are available in a variety of packages; metal can, plastic, and microminiature. Complete device specifications and typical performance curves are given on individual data sheets, which are grouped by the various families.

A quick comparison of performance characteristics is presented in the easy-to-use selector guides in the first section. The tables will assist in the selection of the proper transistor for a specific application.

Separate sections are included to describe package outline drawings, and to clarify the mysteries of high reliability processing and testing.

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The following devices: 2N2405, BCV26, BCV27, BCY56, BCY57, BCY65, BCY66, BCY67, BCY77, BDT70, BDT71, BF178, BF410 Series, BFX29, BFX37, MMBV3700, PO17, PO7644, P2N1893, and more are available from Motorola although not represented in this book.
Please contact your nearest Motorola sales office or distributor for further information.

ALPHANUMERIC INDEX

ALPHANUMERIC INDEX (continued)

ALPHANUMERIC INDEX (continued)

ALPHANUMERIC INDEX (continued)

ALPHANUMERIC INDEX (continued)

ALPHANUMERIC INDEX (continued)

ALPHANUMERIC INDEX (continued)

Motorola Part #	Data Sheet Page #	Selector Guide Page #
BC109	4-203	1-23
BC140	4-205	1-23
BC141	4-205	1-23
BC160	4-206	1-24
BC161	4-206	1-24
BC171	2-62	-
BC172	2-62	-
BC174	2-62	-
BC177	4-207	1-24
BC178	4-207	1-24
BC179	4-207	1-24
BC182	2-64	1-2
BC183	2-64	-
BC184	2-64	-
BC212	2-66	1-2
BC213	2-66	-
BC214	2-66	-
BC237	2-68	1-2
BC238	2-68	1-2
BC239	2-68	1-2
BC251	2-71	-
BC252	2-71	-
BC256	2-71	-
BC264A, B, C, D	6-96	1-32
BC307	2-73	1-2
BC308	2-73	1-2
BC309	2-73	1-2
BC317, A, B	2-76	1-2
BC318, A, B, C	2-76	1-2
BC319, A B	2-76	1-2
BC320, A, B	2-78	1-2
BC321, A, B	2-78	1-2
BC322, B	2-78	1-2
BC327	2-80	1-3
BC328	2-80	1-3
BC337	2-82	1-3
BC338	2-82	1-3
BC368	2-84	1-7
BC369	2-84	1-7
BC372	2-86	1-6
BC373	2-86	1-6
BC393	4-209	1-22
BC394	4-209	1-21
BC413	2-88	1-3
BC414	2-88	1-3
BC415	2-90	1-3
BC416	2-90	1-3
BC445	2-92	1-3
BC446	2-93	1-3
BC447	2-92	1-3
BC448	2-93	1-3
BC449	2-92	1-3
BC450	2-93	1-3
BC485	2-94	1-3
BC486	2-95	1-3
BC487	2-94	1-3
BC488	2-95	1-3
BC489	2-94	1-3
BC490	2-95	1-3
BC517	2-96	1-6

Motorola Part #	Data Sheet Page #	Selector Guide Page #
BC546, A, B	2-97	1-2
BC547, A, B, C	2-97	1-2
BC548, A, B, C	2-97	1-2
BC549, B, C	2-101	1-3
BC550, B, C	2-101	1-3
BC556, A, B	2-106	1-2
BC557, A, B, C	2-106	1-2
BC558, A, B, C	2-106	1-2
BC559, B, C	2-111	1-3
BC560, B, C	2-111	1-3
BC585	2-115	-
BC586	2-115	-
BC617	2-117	1-6
BC618	2-117	1-6
BC635	2-118	1-7
BC636	2-120	1-7
BC637	2-118	1-7
BC638	2-120	-
BC639	2-118	1-7
BC640	2-120	1-7
BC650, S	2-122	1-3
BC651, S	2-122	1-3
BCW29	3-8	1-11
BCW30	3-8	1-11
BCW31	3-9	-
BCW32	3-9	1-11
BCW33	3-9	-
BCW60A	3-10	-
BCW60B	3-10	1-11
BCW60C	3-10	1-11
BCW60D	3-10	-
BCW61A	3-12	-
BCW61B	3-12	1-11
BCW61C	3-12	1-11
BCW61D	3-12	-
BCW65A	3-12	-
BCW65B	3-12	1-11
BCW65C	3-12	1-11
BCW66F, G	3-16	-
BCW67	3-17	-
BCW67A	3-17	-
BCW67B	3-17	1-11
BCW67C	3-17	1-11
BCW68	3-17	-
BCW68F	3-17	-
BCW68G	3-17	-
BCW69	3-18	-
BCW70	3-18	1-11
BCW71	3-19	-
BCW72	3-19	1-10
BCX17	3-20	1-11
BCX18	3-20	1-11
BCX19	3-21	1-10
BCX20	3-21	1-11
BCX25	2-123	-
BCX26	2-125	-
BCX27	2-123	-
BCX28	2-125	-
BCX29	2-123	-
BCX30	2-125	-

ALPHANUMERIC INDEX (continued)

ALPHANUMERIC INDEX (continued)

ALPHANUMERIC INDEX (continued)

ALPHANUMERIC INDEX (continued)

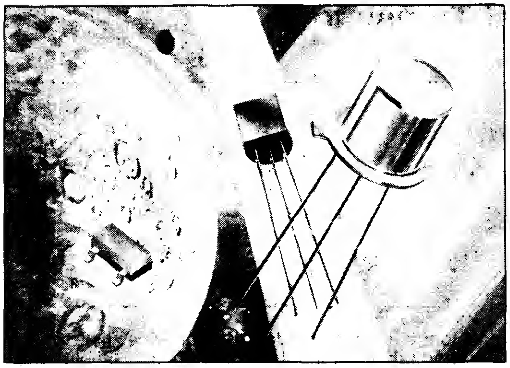
ALPHANUMERIC INDEX (continued)

Motorola Part #	Data Sheet Page #	Selector Guide Page #
MPF4858	6-187	-
MPF4858A	6-187	-
MPF4859	6-187	-
MPF4859A	6-187	-
MPF4860	6-187	-
MPF4860A	6-187	-
MPF4861	6-187	-
MPF4861A	6-187	-
MPF6659	6-70	1-35
MPF6660	6-70	1-35
MPF6661	6-70	1-35
MPF9200	-	1-35
MPQ918	5-102	1-27
MPQ1000	5-102	-
MPQ1500	5-104	-
MPQ2221	5-88	-
MPQ2222	5-88	1-27
MPQ2369	5-90	1-27
MPQ2483	5-105	-
MPQ2484	5-105	1-27
MPQ2906	5-92	-
MPQ2907	5-92	1-27
MPQ3303	5-107	-
MPQ3467	5-108	1-27
MPQ3546	5-95	1-27
MPQ3724	-	-
MPQ3725	5-109	1-27
MPQ3725A	5-109	1-22
MPQ3762	5-111	1-27
MPQ3798	5-113	-
MPQ3799	5-113	1-27
MPQ3904	5-115	1-27
MPQ3906	5-116	1-27
MPQ6001	5-118	1-27
MPQ6002	5-118	1-27
MPQ6100	5-121	1-27
MPQ6100A	5-121	-
MPQ6426	5-123	-
MPQ6427	5-123	-
MPQ6501	5-118	1-27
MPQ6502	5-118	1-27
MPQ6600	5-121	1-27
MPQ6600A	5-121	-
MPQ6700	5-125	-
MPQ6842	5-129	1-27
MPQ7041	5-132	-
MPQ7042	5-132	1-27
MPQ7043	5-132	1-27
MPQ7051	5-133	-
MPQ7052	5-133	1-27
MPQ7053	5-133	1-27
MPQ7091	5-135	-
MPQ7092	5-135	1-27
MPQ7093	5-135	1-27
MPS404	2-178	-
MPS404A	2-178	1-5
MPS650	2-182	1-3
MPS651	2-182	-
MPS750	2-182	1-3
MPS751	2-182	-

Motorola Part #	Data Sheet Page #	Selector Guide Page #
MPS918	2-183	1-5
MPS2222	2-185	1-4
MPS2222A	2-185	1-4
MPS2369, A	2-189	1-5
MPS2714	-	-
MPS2716	-	-
MPS2907	2-191	1-4
MPS2907A	2-191	1-4
MPS3563	2-183	1-5
MPS3638	2-195	-
MPS3638A	2-195	-
MPS3640	2-197	1-5
MPS3646	2-199	-
MPS3702	2-201	-
MPS3703	2-201	-
MPS3704	2-202	-
MPS3705	2-202	-
MPS3706	2-202	-
MPS5172	2-203	-
MPS6512	2-204	-
MPS6515	2-204	-
MPS6516	2-204	-
MPS6519	2-204	-
MPS6520	2-205	-
MPS6521	2-205	-
MPS6522	2-205	-
MPS6523	2-205	-
MPS6530	2-206	-
MPS6531	-	1-4
MPS6532	2-206	1-4
MPS6533	2-207	-
MPS6534	-	1-4
MPS6535	2-207	1-4
MPS8098	2-208	-
MPS8099	2-208	1-3
MPS8598	2-208	-
MPS8599	2-208	1-3
MPSA05	2-213	1-3
MPSA06	2-213	1-3
MPSA12	2-218	1-6
MPSA13	2-219	1-6
MPSA14	2-219	1-6
MPSA16	2-220	-
MPSA17	2-220	-
MPSA18	2-222	1-3
MPSA25	2-226	1-6
MPSA26	2-226	1-6
MPSA27	2-226	1-6
MPSA28	2-228	1-6
MPSA29	2-228	1-6
MPSA42	2-230	1-4
MPSA43	2-230	1-4
MPSA44	2-232	1-4
MPSA45	2-232	1-4
MPSA55	2-213	1-3
MPSA56	2-213	1-3
MPSA62	2-235	1-6
MPSA63	2-235	1-6
MPSA64	2-235	1-6
MPSA75	2-236	1-6

ALPHANUMERIC INDEX (continued)

ALPHANUMERIC INDEX (continued)



The following selector guides highlight transistors that have emerged as the best values in their various categories. Semiconductors are manufactured by "batch" processes; therefore, each "batch" may yield devices with widely varying parameters, creating "families".

A large selection of plastic-encapsulated transistors is offered (TO-92, 1 Watt TO-92, SOT-23, SOT-89, Duals, and Quads).

For those applications where higher power dissipation and hermeticity are required, Motorola offers a full line of transistors in several metal-can packages.

FET's include devices developed for operation from dc to UHF in switching and amplifying applications.

A broad line of high frequency (RF) transistors with F_T's up to 8 GHz are included for amplifiers, oscillators, mixers and switching applications.

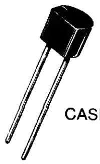
Devices which are qualified to JAN, JANTX, JANTXV, and JANS high reliability specifications are so noted in the applicable selector guide which includes also a list of CECC qualified types.

Selector Guides

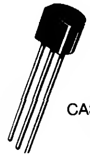
1

Table of Contents

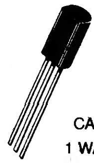
Plastic-Encapsulated Small-Signal Transistors



CASE 182



CASE 29-02
TO-92



CASE 29-03
1 WATT TO-92

Motorola's small-signal TO-92 plastic transistors encompass hundreds of devices with a wide variety of characteristics for general purpose, amplifier and switching applications. The popular high-volume TO-92 package combines proven reliability, performance, economy and convenience to provide the perfect solution for industrial and consumer design problems. All Motorola TO-92 devices are laser marked for ease of identification and shipped in antistatic containers, as part of Motorola's ongoing practice of maintaining the highest standards of quality and reliability.

In addition to the standard TO-92 devices listed in the following tables, Motorola also offers special electrical selections of these devices. Please contact your Motorola Sales Representative regarding any special requirements you may have.

In each of the following tables, the major specifications of the TO-92 transistor are given for easy comparison.

Motorola TO-92 transistors are available in the radial or axial tape and reel formats. Lead forming to fit TO-5 or TO-18 sockets is also available.

TABLE 1. General Purpose Amplifier Transistors (TO-92)

The general purpose Transistors are designed for small-signal amplification from D.C. to low radio frequencies. They are also useful as oscillators and general purpose switches.

NPN	PNP	BV_{CEO} (Volts)	P_d (mW)	I_C max. (mA) Cont.	H_{FE}@ I_C = 2.0 mA, V_{CE} = 5 V		F_T Typ. MHz	N_F Max. (dB)	Pin Out
					Min.	Max.			
BC182	BC212	50	625	100	120	460	200	10	CBE
BC237	BC307	45	625	100	120	460	200	10	CBE
BC238	BC308	25	625	100	120	800	200	10	CBE
BC239	BC309	45	625	100	180	800	240	4	CBE
BC546	BC556	65	625	100	120	450	300	10	CBE
BC546A	BC556A	65	625	100	120	220	300	10	CBE
BC546B	BC556B	65	625	100	180	450	300	10	CBE
BC547	BC557	45	625	100	120	450	300	10	CBE
BC547A	BC557A	45	625	100	120	220	300	10	CBE
BC547B	BC557B	45	625	100	180	450	300	10	CBE
BC547C	BC557C	45	625	100	380	800	300	10	CBE
BC548	BC558	30	625	100	120	800	300	10	CBE
BC548A	BC558A	30	625	100	120	220	300	10	CBE
BC548B	BC558B	30	625	100	180	450	300	10	CBE
BC548C	BC558C	30	625	100	380	800	300	10	CBE
BC317	BC320	45	625	150	110	450	250	6	EBC
BC318	BC321	30	625	150	110	800	250	6	EBC
BC319	BC322	20	625	150	200	800	250	4	EBC

TABLE 2. Low Noise and Good H_{FE} Linearity

These devices are designed to use on applications where good H_{FE} linearity and low noise characteristics are required: Instrumentation, Hi-Fi Preamplifier.

NPN	PNP	BV_{CEO} (Volts) Amb.	P_d mW 25°C Min.	H_{FE}@ I_C = 10 µA, V_{CE} = 5 V Min.	Typ.	H_{FE}@ I_C = 2 mA, V_{CE} = 5 V Min.	Max.	V_T 120 Hz[1] Typ.	mV Max.	N_F (dB)[2] Typ.	Max.	F_T Typ. (MHz)	Pinning
BC239	BC309	45	625	—	—	120	800	9.5	—	2	4	240	CBE
BC413	BC415	30	625	100	—	180	800	8	12	0.6	2.5	250	CBE
BC414	BC416	45	625	100	—	180	800	8	12	0.6	2.5	250	CBE
BC549	BC559	30	625	100	—	180	800	8	12	0.6	2.5	250	CBE
BC549B	BC559B	30	625	100	150	180	460	8	12	0.6	2.5	250	CBE
BC459C	BC559C	30	625	100	270	380	800	8	12	0.6	2.5	250	CBE
BC550	BC560	45	625	100	—	180	800	8	12	0.6	2.5	250	CBE
BC550B	BC560B	45	625	100	150	180	460	8	12	0.6	2.5	250	CBE
BC550C	BC560C	45	625	100	270	380	800	8	12	0.6	2.5	250	CBE
BC650	—	30	625	—	—	380	1400	—	7.6(6.8*)	—	1(§)	300	EBC
BC651	—	45	625	—	—	380	1400	—	7.6(6.8*)	—	1(§)	300	EBC
MPSA18	—	45	625	400	500	500	—	7	—	—	1.5	160	EBC
2N4123	2N4125	30	625	—	—	50	150[3]	—	—	—	6	300	EBC
2N4124	2N4126	25	625	—	—	120	360[3]	—	—	—	5	350	EBC
2N5088	—	30	625	300	900	350	—	—	—	—	3	150	EBC
2N5089	—	25	625	400	1200	450	—	—	—	—	2	150	EBC

[1] V_T: Total Input Noise Voltage (see Application Note, BC413/BC414 and BC415/BC416 Data Sheets) at R_S = 2 KΩ, I_C = 200µA, V_{CE} = 5 Volts.
[2] N_F: Noise Figure at R_S = 2K, I_C = 200 µA, V_{CE} = 5 Volts. F = 30 Hz to 15 KHz.
[3] At V_{CE} = 1 V.
* "S" version.
(§) @ 1 KHz.

TABLE 3. High Current Amplifier Transistors (TO-92)

Useful in Low Power Audio Output Stages and Medium Current Switches.

NPN	PNP	BV_{CEO} (Volts)	P_D mW 25°C Amb.	I_C (mA) Cont.	H_{FE} Min.	Max.	@I_C (mA)	V_{CE} (Volts)	F_T Typical (MHz)	Pinning
BC337	BC327	45	625	800	100	600	100	1	210	CBE
BC338	BC328	25	625	800	100	600	100	1	210	CBE
BC445	BC446	60	625	300	70	—	10	5	250/200[1]	CBE
BC447	BC448	80	625	300	70	—	10	5	250/200[1]	CBE
BC449	BC450	100	625	300	70	—	10	5	250/200[1]	CBE
BC485	BC486	45	625	1000	60	400	100	2	200/150[1]	CBE
BC487	BC488	60	625	1000	60	400	100	2	200/150[1]	CBE
BC489	BC490	80	625	1000	60	400	100	2	200/150[1]	CBE
MPSA05	MPSA55	60	625	500	50	—	100	1	150/175[1]	EBC
MPSA06	MPSA56	80	625	500	50	—	100	1	150/175[1]	EBC
MPS8099	MPS8599	80	625	500	75	—	100	5	200	EBC
2N4409	—	50	625	250	60	400	10	1	200	EBC
2N4410	—	80	625	250	60	400	10	1	200	EBC
MPS650	MPS750	40	625	2000	75	—	1000	2	100	EBC
					40	—	2000	2		

[1] Relevant to PNP.

TABLE 4. High Voltage Amplifier Transistors (TO-92 · EBC)*

These high-voltage transistors are designed for driving neon bulbs and Nixie® indicator tubes, for direct line operation, and for other applications requiring high-voltage capability at relatively low collector current. These devices are listed in order of decreasing breakdown voltage (BV_{CEO}).

Device Type	BV_{CEO} Volts Min.	I_C Amp Cont.	h_{FE} Min.	@ I_C mA	V_{CE} (sat) Volts Max.	@ I_C mA	& I_B mA	f_T MHz Min.	@ I_C mA
NPN									
BF844	400	0.5	40	30	0.5	10	1	50	10
MPSA44	400	0.3	40	100	0.75	50	5	20	10
BF845	350	0.5	40	30	0.5	10	1	50	10
MPSA45	350	0.3	50	100	0.75	50	5	20	10
2N6517	350	0.5	30	30	0.3	10	1	40	10
BF393	300	0.5	40	10	0.2	20	2	50	10
MPS-A42	300	0.5	40	30	0.5	20	2	50	10
2N6516	300	0.5	45	30	0.3	10	1	40	10
BF392	250	0.5	40	10	0.2	20	2	50	10
2N6515	250	0.5	50	30	0.3	10	1	40	10
BF391	200	0.5	40	10	0.2	20	2	50	10
MPS-A43	200	0.5	40	10	0.4	20	2	50	10
2N5551	160	0.6	80	10	0.15	10	1	100	10
2N5550	140	0.6	60	10	0.15	10	1	100	10
MPS-L01	100	0.15	20	30	0.2	10	1	40	10
PNP									
BF493S	350	0.5	40	10	2.0	20	2	50	10
2N6520	350	0.5	30	30	0.3	10	1	40	10
BF493	300	0.5	40	10	0.2	20	2	50	10
MPS-A92	300	0.5	40	10	0.5	20	2	50	10
2N6519	300	0.5	45	30	0.3	10	1	40	10
BF492	250	0.5	40	10	0.2	20	2	50	10
2N6518	250	0.5	50	30	0.3	10	1	40	10
BF491	200	0.5	40	10	0.2	20	2	50	10
MPS-A93	200	0.5	40	10	0.4	20	2	50	10
2N5401	150	0.6	60	10	0.2	10	1	100	10
2N5400	120	0.6	40	10	0.2	10	1	100	10
MPS-L51	100	0.6	40	50	0.25	10	1	60	10

* ECB PIN OUT (BF420/1/2/3): Table 10.
CBE PIN OUT (PBF259/493): Table 11.

TABLE 5. Industrial Transistors (TO-92)

These devices are special products ranges intended for use in applications which require well specified high performing devices like high quality amplifier differential input, driver stage.

NPN	PNP	BV_{CEO} (Volts)	P_D mW 25°C Amb.	I_C (mA) Cont.	H_{FE} Min.	H_{FE} Max.	@ I_C (mA)	V_{CE} (Volts)	F_T Typ. (MHz)	Typ. (dB)	Pin Out	T_{ON} Typ. (nS)	T_{OFF} Typ. (nS)
BCX25	BCX26	60	625	200	70	400	10	5	250	2	CBE	70	1000/600
BCX27	BCX28	80	625	200	70	400	10	5	250	2	CBE	70	1000/600
BCX29	BCX30	100	625	200	70	400	10	5	250	2	CBE	70	1000/600
BCX45	BCX46	45	625	1000	50	—	100	2	150	2	CBE	30	380
BCX47	BCX48	60	625	1000	50	—	100	2	150	2	CBE	30	380
BCX49	BCX50	80	625	1000	50	—	100	2	150	2	CBE	30	380
BCX58	BCX78	32	625	200	120	630	2	5	250	2	CBE	75	600/350
BCX59	BCX79	45	625	200	120	630	2	5	250	2	CBE	75	600/350
MPS2222	—	30	625	600	75	—	10	10	250*	—	EBC	30	270
MPS2222A	—	40	625	600	75	—	10	10	300*	—	EBC	30	270
—	MPS2907	40	625	600	75	—	10	10	200*	—	EBC	45	100
—	MPS2907A	60	625	600	100	—	10	10	200*	—	EBC	45	100
MPS6531	MPS6534	40	625	600	90	270	100	1	250	—	EBC	30	250
MPS6532	MPS6535	30	625	600	30	—	100	1	250	—	EBC	30	250

* F_T Min.

TABLE 6. RF Transistors

The RF transistors are designed for Small Signal amplification from RF to VHF/UHF frequencies. They are also used as mixers and oscillators in the same frequency ranges. Several types are AGC characterised. The transistors are listed in order of decreasing F_T Min.

Device Type	Pin Out	BV_{CEO} min. Volts	P_d max. mW	I_C max. mA	H_{FE} Min.	@ I_C mA	V_{CE} Volts	F_T typ MHz	C_{RE} C_{RB} pF Max.	N_F typ dB	F MHz
NPN											
MPSH17	BEC	15	625	100	25	5	10	1600	0.9	6*	200
MPSH10	BEC	25	625	100	60	4	10	1500	0.7	—	—
BF374	BEC	25	625	100	70	1	10	800	0.6	4	100
BF375	BEC	25	625	100	35	1	10	800	0.6	4	100
BF959	CEB	20	625	100	40	20	10	800	0.65(§)	3	200
MPS918	EBC	15	625	50	20	8	10	800	1.7	6*	60
MPS3563	EBC	12	625	50	20	8	10	800	1.7	6*	60
BF199	CEB	25	625	100	40	7	10	750	0.35	2.5	35
BF373	BEC	45	625	100	38	7	10	720	0.32	—	—
BF371	BEC	30	625	100	38	7	10	720	0.23(§)	—	—
BF240	CEB	40	625	25	65	1	10	600	0.34	2.5	100
BF224	CEB	30	625	50	30	7	10	600	0.28(§)	2.5	100
BF241	CEB	40	625	25	35	1	10	470	0.34	2.5	100
BF254	CEB	20	625	100	65	1	10	260	0.9(§)	1.7	1
BF255	CEB	20	625	100	35	1	10	200	0.9(§)	1.7	1
PNP											
BF509	CBE	35	625	50	20	3	10	850	0.25	2.5*	200
MPSH81	BEC	20	625	50	60	5	10	700	0.85	—	—
BF506	CBE	35	625	50	20	3	10	600	0.25	4*	200
MPSH54	EBC	80	625	100	30	1.5	10	130	1.6	2*	1

(§) Typ.
* Max.

TABLE 7. High-Speed Saturated Switching Transistors

The transistors listed in this table are specially optimized for high-speed saturated switches. They are heavily gold doped and processed to provide very short switching times and low output capacitance (below 6 pF). The transistors are listed in order of decreasing turn-on time (t_{on}).

Device Type	t_{on} ns Max. &	t_{off} ns Max. @	I_C mA	BV_{CEO} Volts Min.	h_{FE} Min. @	I_C mA	$V_{CEO(sat)}$ Volts Max. @	I_C mA &	I_B mA	f_T MHz Min. @	I_C mA
NPN											
2N3904	70	250	10	40	100	10	0.2	10	1	300	10
2N3903	70	225	10	40	50	10	0.2	10	1	250	10
2N4400	35	255	150	40	50	150	0.4	150	15	200	20
MPS2369	12	18	10	15	40	10	0.25	10	1	500	10
PNP											
MPS404A	223*	835*	10	25¹	30	12	0.2	24	1	—	—
2N3906	70	250	10	40	100	10	0.25	10	1	250	10
2N3905	70	225	10	40	100	10	0.25	10	1	200	10
2N4402	35	255	150	40	50	150	0.4	150	15	150	20
MPS3640	25	35	50	12	30	10	0.2	10	1	500	10

¹ BV_{EBO}
* Typ.

TABLE 8. Darlington Transistors (TO-92)

Darlington amplifiers are cascade transistors used in applications requiring very high gain and input impedance. These devices have monolithic construction.

Device Type	Pin Out	Absolute Max. Rating at 25°C: Max PD Free Air at 25°C (mW)	Absolute Max. Rating at 25°C: Max I_C (mA)	BVCEO (V)	H_{FE}(1) Bias V_{CE} (V)	H_{FE}(1) Bias I_C (mA)	H_{FE}(1) Min.	H_{FE}(1) Max.	V_{CEsat} Bias I_C (mA)	V_{CEsat} Bias I_B (mA)	V_{CEsat} Max. V	F_T I_C (mA)	F_T Min. (MHz)	Complementary Device Type
NPN														
BC372	EBC	625	1000	100	5.0	100	25 K	160 K	250	0.25	1.0	100	100	
BC373	EBC	625	1000	80	5.0	100	25 K	160 K	250	0.25	1.0	100	100	
BC617	CBE	625	1000	40	5.0	200	20 K	70 K	200	0.20	1.1	500	150	
BC618	CBE	625	1000	55	5.0	200	10 K	50 K	200	0.20	1.1	500	150	
2N6426	EBC	625	500	40	5.0	100	30 K	300 K	500	0.50	1.5	10	125	
2N6427	EBC	625	500	40	5.0	100	20 K	200 K	500	0.50	1.5	10	125	
MPSA12	EBC	625	500	20(3)	5.0	10	20 K	—	10	0.01	1.0	10	125	MPSA62
MPSA13	EBC	625	500	30(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA63
MPSA14	EBC	625	500	30(3)	5.0	100	20 K	—	100	0.10	1.5	10	125	MPSA64
MPSA25	EBC	625	500	40(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA75
MPSA26	EBC	625	500	50(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA76
MPSA27	EBC	625	500	60(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA77
MPSA28	EBC	625	500	80(3)	5.0	100	10 K	—	100	0.10	1.4	10	125	
MPSA29	EBC	625	500	100(3)	5.0	100	10 K	—	100	0.10	1.4	10	125	
BC517	CBE	625	400	30(4)	2.0	20	30 K	—	100	0.10	1.0	10	125	
PNP														
MPSA62	EBC	625	500	20(3)	5.0	10	5 K	—	10	0.01	1.0	100	125	MPSA12
MPSA63	EBC	625	500	30(3)	5.0	100	10 K	—	100	0.10	1.5	100	125	MPSA13
MPSA64	EBC	625	500	30(3)	5.0	100	20 K	—	100	0.10	1.5	100	125	MPSA14
MPSA75	EBC	625	500	40(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA25
MPSA76	EBC	625	500	50(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA26
MPSA77	EBC	625	500	60(3)	5.0	100	10 K	—	100	0.10	1.5	10	125	MPSA27

(1) Pulse Test/Pulse Width ≤ 300 μs — Duty Cycle ≤ 2.0% (3) BVCES @ IC = 100 μ (4) BVCES @ IC = 2 mA.
(2) NF I_C = 100 μA: VCE = 5 v, RS = 10 K, F = 10 Hz to 15.7 KHz.

TABLE 9. Dual Diodes

Dual diodes designed for use in low cost biasing, steering and voltage doubler applications including series, common cathode and common anode diodes.

Device Type	$V_{(BR)}$ Volts Min.	@ $I_{(BR)}$ μA	I_R μA Max.	@ V_R Volts	V_F@ Volts Min./Max.	I_F mA	C_{VR} = 0 pF Max.	t_{rr} ns Max.	Description
MSD6100	100	100	0.1	50	0.67/0.82	10	1.5	4.0	Switching
MSD6102	70	100	0.1	50	0.76/1.0	10	3.0	100	Common Cathode
MSD6150	70	100	0.1	50	—/1.0	10	8.0	100	Common Anode

TABLE 10. Central Collector 800 MW TO-92

The transistors listed in this table have been designed to provide power dissipation. These devices are listed in order of decreasing breakdown voltage (BVCEO).

Device Type	BV_{CEO} Volts Min.	I_C Amp Cont.	h_{FE} Min.	@ I_C mA	$V_{CE(sat)}$ Volts Max.	@ I_C mA	@ I_B mA	f_T MHz Min.	@ I_C mA	PIN OUT
NPN										
BF420	300	0.1	40	25	2.0	20	2	60	10	ECB
BF422	250	0.1	50	25	2.0	20	2	60	10	ECB
BC639	80	1.0	40	150	0.5	500	50	60	10	ECB
BC637	60	1.0	40	150	0.5	500	50	60	10	ECB
BC635	45	1.0	40	150	0.5	500	50	60	10	ECB
BC368	20	1.0	60	1000	0.5	1000	100	65	10	ECB
PNP										
BF421	300	0.1	40	25	2.0	20	2	60	10	ECB
BF423	250	0.1	50	25	2.0	20	2	60	10	ECB
BC640	80	1.0	40	150	0.5	500	50	60	10	ECB
BC639	60	1.0	40	150	0.5	500	50	60	10	ECB
BC636	45	1.0	40	150	0.5	500	50	60	10	ECB
BC369	20	1.0	60	1000	0.5	1000	100	65	10	ECB

TABLE 11. Telecom Transistors (TO92)

These devices are special product ranges intended for use in Telecom application which require an excellent long term reliability.

NPN DEVICES	PNP DEVICES	BVCEO V	PDmW 25°C Amb	IC (mA) Cont	HFE				F_T Min MHz	PIN OUT
					min	max	IC (mA)	VCE (V)		
P2N2222		30	625	600	75	—	10	10	250	CBE
P2N2222A		40	625	600	75	—	10	10	300	CBE
	P2N2907	40	625	600	75	—	10	10	200	CBE
	P2N2907A	60	625	600	100	—	10	10	200	CBE
(1)PBF259,S		300	625	500	25	—	1	10	40	EBC
(1)PBF259R,RS		300	625	500	25	—	1	10	40	CBE
	(2)PBF493,S	300	625	500	40	—	1	10	40	EBC
	(2)PBF493R,RS	300	625	500	40	—	1	10	40	CBE

(1) "S" version, HFE Min 60 @ Ic = 20 mA, V_{CE} = 10 V.
(2) "S" version, HFE Min 40 @ Ic = 0,1 mA, V_{CE} = 1 V.

TABLE 12. Voltage Reference Diodes (TO92)

These devices are highly reliable temperature compensated monolithic integrated circuit voltage stabiliser designed for use in television and FM radios that use variable capacitance diode tuners.

Device Type	P_D (mW)	Vz (V)			Δ Vz/ΔT (mV/°C)			
		Min	Max	@ I_{ZT} (mA)	Type	@ I_{ZT} (mA)	T/Min (°C)	T/Max (°C)
MVS240	625	23	25	5	−0.2	5	0	70
MVS460	625	31	35	5	−2.3	5	0	70
MVS460-1	625	31	32	5	−2.3	5	0	70
MVS460-2	625	32	34	5	−2.3	5	0	70
MVS460-3	625	34	35	5	−2.3	5	0	70

TABLE 13. TO 92 - 1 Watt Package

High-Current

EUROPEAN VERSION PIN OUT ECB	EBC	PNP/ NPN	BVCEO (V)	IC Max (A)	ICBO max (nA)	ICBO VCB	HFE min	HFE max	HFE IC(mA)	HFE VCE (V)	VCEsat maxV	VCEsat ICmA	VCEsat IB (mA)	F_T min MHz	F_T IC (mA)
BDC01A	BDB01A	N	45	1.5	100	45	40	400	100	1	0.7	1000	100	50	200
BDC02A	BDB02A	P													
BDC01B	BDB01B	N	60	1.5	100	60	40	400	100	1	0.7	1000	100	50	200
BDC02B	BDB02B	P													
BDC01C	BDB01C	N	80	1.5	100	80	40	400	100	1	0.7	1000	100	50	200
BDC02C	BDB02C	P													
BDC01D	BDB01D	N	100	1.5	100	100	40	400	100	1	0.7	1000	100	50	200
BDC02D	BDB02D	P													
	BDB03	N	45	1.0	100	45	100	300	150	10	1.1	150	15	150	15
	BDB04	P													
BDC03		N	20	1.0	100	25	60	—	1000	1	0.5	1000	100	50	50
BDC04		P	20	1.0	100	25	60	—	1000	1	0.7	1000	100	50	50
US VERSION															
DEVICE	**PIN OUT**														
MPSW01	EBC	N	30	1.0	100	30	50	—	1000	1	0.5	1000	100	50	50
MPSW51	EBC	P	30	1.0	100	30	50	—	1000	1	0.7	1000	100	50	50
MPSW01A	EBC	N	40	1.0	100	40	50	—	1000	1	0.5	1000	100	50	50
MPSW51A	EBC	P	40	1.0	100	40	50	—	1000	1	0.7	1000	100	50	50
MPSW05	EBC	N	60	0.5	100	40	80	—	50	1	0.4	250	10	50	200
MPSW55	EBC	P	60	0.5	100	40	80	—	50	1	0.5	250	10	50	250
MPSW06	EBC	N	80	0.5	100	60	80	—	50	1	0.4	250	10	50	200
MPSW56	EBC	P	80	0.5	100	60	80	—	50	1	0.5	250	10	50	250

High-Voltage

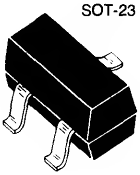
EUROPEAN VERSION					ICBO		HFE				VCEsat			FT	
DEVICE	PIN OUT	POLA	BVCEO (V)	IC Max (A)	max (nA)	VCB	min	max	VCE (V)	IC(mA)	max(V)	IC(mA)	IB (mA)	min MHz	IC (mA)
BDC05	ECB	N	300	0.5	10	200	40	—	20	25	2	20	2	60	10
BDC06	ECB	P	300	0.5	10	200.	40	—	20	25	2	20	2	60	10
BDC07	ECB	N	250	0.5	10	200	50	—	20	25	2	20	2	60	10
BDC08	ECB	P	250	0.5	10	200	40	—	20	25	2	20	2	60	10
US VERSION															
DEVICE	PIN OUT														
MPSW42	EBC	N	300	0.5	100	200	40	—	10	30	0.5	20	2	50	10
MPSW92	EBC	P	300	0.5	250	200	25	—	10	30	0.5	20	2	50	10
MPSW43	EBC	N	200	0.5	100	160	40	—	10	30	0.5	20	2	50	10
MPSW93	EBC	P	200	0.5	250	160	25	—	10	30	0.5	20	2	50	10
MPSW10	EBC	N	300	0.5	200	200	40	—	10	30	0.75	30	3	45	10
MPSW60	EBC	P	300	0.5	200	200	25	—	10	30	0.75	20	2	60	10

Darlington

US VERSION					ICBO		HFE				VCEsat			FT	
DEVICE	PIN OUT	POLA	BVCEO (V)	IC Max (A)	max (nA)	VCB	min	max	IC(mA)	VCE (V)	max(V)	IC(mA)	IB (mA)	min MHz	IC (mA)
MPSW13 MPSW63	EBC EBC	N P	30	1	100	30	10K	—	100	5	1.5	100	0.1	125	10
MPSW14 MPSW64	EBC EBC	N P	30	1	100	30	20K	—	100	5	1.5	100	0.1	125	10
MPSW45	EBC	N	40	1	100	30	25K	150K	200	5	1.5	1000	2	100	200
MPSW45A	EBC	N	50	1	100	30	15K	—	500	5	1.5	1000	2	100	200

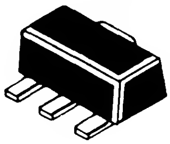
Microminiature Products

SOT-23



CASE 318
TO-236AA
TO-236AB

SOT-89



CASE 345-01

Microminiature Space Saving Alternatives for Discrete Devices

A wide variety of discrete components from Motorola's repertoire of reliability-proven semiconductor processes and geometries are available in SOT (Small Outline Transistor) packages. Products include Bipolar and Field-Effect Transistors; Switching, Zener and Varactor Diodes; and Silicon Controlled Rectifiers. The surface-mounted SOT devices are currently being used by circuit designers on Printed Circuit Boards and Ceramic Substrate.

Some of the significant features of the SOT devices are:

- li*Complete Pretest Capability* — all SOT's are 100% electrically tested.
- *Handling and Assembly Ease* — SOT's can be placed on substrates either manually or by using automated handling equipment.
- *Reliability* — SOT's are subjected to the same rigid reliability test performed on all Motorola plastic packages.
- *Small Size/Less Weight* — Considerable size reduction and weight-saving is achieved in circuit designs using SOT technology.
- *Broad Line* — Currently, Motorola offers over 250 standard discrete devices in the SOT packages. (Inquiries regarding customers' special requirements are invited.)
- *Marking Capability* — A multi-digit code is *laser* marked on every SOT device.
- *Multi-Sources* — Although Motorola was the first domestic supplier of SOT's, today there are several U.S. manufacturers, as well as many foreign sources for these devices.
- *Packaging* — Motorola standard shipping method for SOT's is in vials; additionally, in conjunction with the industry trend to use automatic placement equipment for microminiature components, Motorola offers the SOT-23 packaged in the 8mm tape and reel format.
- *Standard SOT-23 VS Low Profile SOT-23* — Motorola offers both the standard SOT-23 outline (TO-236AA) and the new "Low Profile" SOT-23 (TO-236AB). The only difference is the clearance from the bottom of the package to the surface of the substrate:

Device	Millimeters		Inches	
	Min	Max	Min	Max
Standard SOT-23	0.10	0.25	0.004	0.0098
Low Profile SOT-23	0.01	0.10	0.0005	0.0040

The "Low Profile" package is primarily designed for customers using two-sided printed circuit boards with the SOT-23's mounted on the "bottom side" of the board, and with the nonsurface mounted device on the "top side." Contact your Motorola representative for ordering instructions on "Low Profile" SOT-23's.

TABLE 1. General-Purpose SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of descending breakdown voltage.

NPN

Device Type	Marking	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
BCX70J	AJ	45	250	460	2	125
BCW72	K2	45	200	450	2	—
BCX70H	AH	45	180	310	2	125
BCX70G	AG	45	120	220	2	125
BCX19	U1	45	100	600	100	200
MMBT2222A	1P	40	100	300	150	200
MMBT3904	1A	40	100	300	10	200

MICROMINIATURE PRODUCTS (continued)

TABLE 1. General-Purpose SOT-23 Transistors (continued)

Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of descending breakdown voltage.

NPN

Device Type	Marking	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
BCW60C	AC	32	250	460	2	125
BCW65C	EC	32	250	630	100	100
BCW60B	AB	32	180	310	2	125
BCW65B	EB	32	160	400	100	100
MMBT2222	1B	30	100	300	150	250
BCX20	U2	25	100	600	100	—
MMBT4124	ZC	25	60	—	50	300
BCW32	D2	20	200	450	2	—

PNP

Device Type	Marking	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
MMBT2907A	2F	60	100	300	150	200
BCX71J	BJ	45	250	460	2	—
BCW70	H2	45	215	500	2	—
BCX71H	BH	45	180	310	2	—
BCX17	T1	45	100	600	100	100
MMBT2907	2B	40	100	300	150	200
MMBT3906	2A	40	100	300	10	250
BCW61C	BC	32	250	460	2	—
BCW67C	EC	32	250	630	100	100
BCW61B	BB	32	180	310	2	—
BCW67B	DB	32	160	400	100	100
BCX18	T2	25	100	600	100	—
BCW30	C2	20	215	500	2	—
BCW29	C1	20	120	260	2	—

TABLE 2. SOT-23 Switching Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	Switching Time (ns) T_{ON}	Switching Time (ns) T_{OFF}	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
MMBT2369	1J	12	18	15	40	120	10	—
BSX39	02	12	18	14	40	200	10	—
BSV52	B2	12	18	12	40	120	10	400

PNP

Device	Marking	Switching Time (ns) T_{ON}	Switching Time (ns) T_{OFF}	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
MMBT3640	2J	25	35	12	30	120	10	500

MICROMINIATURE PRODUCTS (continued)

TABLE 3. SOT-23 Transistors, VHF/UHF Amplifiers, Mixers, Oscillators
Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	f_T Min (GHz)	f_T @ I_C (mA)	$V_{BR(CEO)}$	C_{ob} Max (pF)
MMBT3960A	1T	1.600	30	8	2.00
MMBT3960	15	1.600	30	3	2.00
MMBT6543	3F	0.750	4	25	1.00
MMBTH10	3E	0.650	4	25	.70
MMBC1321Q2	Q2	0.600	2	25	1.80
MMBC1321Q3	Q3	0.600	2	25	1.80
MMBC1321Q4	Q4	0.600	2	25	1.80
MMBC1321Q5	Q5	0.600	2	25	1.80
MMBT918	3B	0.600	4	15	1.70
MMBTH24	3A	0.400	8	30	.36
MMBC1009F1	F1	0.150	1	25	3.50
MMBC1009F2	F2	0.150	1	25	3.50
MMBC1009F3	F3	0.150	1	25	3.50
MMBC1009F4	F4	0.150	1	25	3.50
MMBC1009F5	F5	0.150	1	25	3.50

PNP

Device	Marking	f_T Min (GHz)	f_T @ I_C (mA)	$V_{BR(CEO)}$	C_{ob} Max (pF)
MMBT4260	2R	2.000	10	10	2.50
MMBT4261	2S	2.000	10	10	2.50
MMBTH81	3D	0.600	5	20	.85

TABLE 4. Chopper Transistors
Pinout: 1-Base, 2-Emitter, 3-Collector

PNP

Device	Marking	$V_{BR(EBO)}$	$V_{BR(CEO)}$	H_{FE} Min	H_{FE} Max	H_{FE} @ I_C (mA)
MMBT404	2M	12	24	30	400	12
MMBT404A	2N	25	35	30	400	12

TABLE 5. SOT-23 Darlington Transistors
Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	H_{FE} Min	H_{FE} Max	H_{FE} @ I_C (mA)	$V_{BR(CEO)}$	$V_{CE(sat)}$ Max (V)
MMBTA14	1N	20 K	—	100	30	1.5
MMBT6427	1V	10 K	100 K	10	40	1.5
MMBTA13	1M	10 K	—	100	30	1.5

PNP

Device	Marking	H_{FE} Min	H_{FE} Max	H_{FE} @ I_C (mA)	$V_{BR(CEO)}$	$V_{CE(sat)}$ Max (V)
MMBTA64	2V	10 K		10	30	1.5
MMBTA63	2U	5.0 K		10	30	1.5

TABLE 6. Low-Noise SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	NF dB (Typ)	$V_{BR(CEO)}$	H_{FE} Min	Max	@ I_C (mA)	f_T Min (MHz)
MMBT5088	1Q	1.0	30	300	900	1.0	50
MMBT5089	1R	1.0	25	400	1200	1.0	50
MMBT2484	1U	3.0	60	100	600	0.01	15
MMBT6428	1K	3.0	50	250	650	1.0	100
MMBT6429	1L	3.0	45	500	1250	1.0	100

PNP

Device	Marking	NF dB (Typ)	$V_{BR(CEO)}$	H_{FE} Min	Max	@ I_C (mA)	f_T Min (MHz)
MMBT5087	2Q	1.0	50	250	800	1.0	40
MMBT5086	2P	1.5	50	150	500	1.0	40

TABLE 7. High-Voltage SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	$V_{BR(CEO)}$	h_{FE} Min	Max	@ I_C (mA)	f_T Min (MHz)
MMBTA42	1D	300	40	—	10	50
MMBTA43	1E	200	40	—	10	50
MMBC1654N5	N5	160	150	330	15	120
MMBC1654N6	N6	160	100	220	15	120
MMBC1654N7	N7	160	50	130	15	120
MMBT5550	1F	150	60	250	10	100
MMBC1653N2	N2	130	150	330	15	120
MMBC1653N3	N3	130	100	220	15	120
MMBC1653N4	N4	130	50	130	15	120

PNP

Device	Marking	$V_{BR(CEO)}$	h_{FE} Min	Max	@ I_C (mA)	f_T Min (MHz)
MMBTA92	2D	300	40	—	10	50
MMBTA93	2E	200	40	—	10	50
MMBT5401	2L	150	60	240	10	100

TABLE 8. SOT-23 Driver Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	$V_{BR(CEO)}$	h_{FE} Min	Max	@ I_C (mA)	f_T Min (MHz)
MMBTA06	1G	80	50	—	10	100
BSS64	AM	80	20	80	4.0	50
MMBTA05	1H	60	50	—	10	100

PNP

Device	Marking	$V_{BR(CEO)}$	h_{FE} Min	Max	@ I_C (mA)	f_T Min (MHz)
BSS63	BM	100	30	—	10	50
MMBTA56	2G	80	50	—	10	100
MMBTA55	2H	60	50	—	10	100

MICROMINIATURE PRODUCTS (continued)

TABLE 9. RF SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	f_T Typ (GHz)	f_T I_C (mA)	f_T V_{CE} (V)	NF Typ (dB)	NF @ I_C (mA)	NF V_{CE} (V)	Mag Typ (dB)	Mag @ I_C (mA)	Mag V_{CE} (V)	f (MHz)
MMBR930	7C	5.5	30	5.0	1.9	2.0	5.0	15.5	30	5.0	500
BFR92	P1	4.5	14	10	3.0	3.0	1.5	—	—	—	—
BFR93	R1	4.5	30	5.0	3.0	2.0	5.0	—	—	—	—
MMBR931	7D	3.5	1.0	1.0	2.7	0.5	1.0	18	1.0	1.0	500
MMBR2060	7E	2.5	20	10	2.0	1.5	10	13	20	10	500
MMBR5179	7H	1.5	5.0	6.0	4.0	1.5	6.0	11.0	5.0	6.0	450
MMBR920	7B	5.0	14	10	2.4	2.0	10	17	14	10	1000
MMBR901	7A	4.0	15	10	2.3	5.0	6.0	10.5	15	10	1000
MMBR5031	7G	2.0	5.0	6.0	1.9	1.0	6.0	13.5	5.0	6.0	450
MMBR2857	7K	1.0	4.0	10	—	—	—	—	—	—	—
BFS17	E1	1.0	2.0	5.0	5.0	2.0	5.0	—	—	—	30
PNP											
MMBR4957	7F	2.0	2.0	10	2.5	2.0	10	14.5	2.0	10	450

TABLE 10. RF Junction Field-Effect SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

N-CHANNEL

Device	Marking	NF Typ (dB)	NF f (MHz)	Y_{fs} Min (mmhos)	Y_{fs} Max (mmhos)	Y_{fs} V_{DS} (V)	$V_{(BR)GSS}$
MMBFU310	6C	1.5	100	10	18	10	−25
MMBF5484	6B	2.0	100	3.0	6.0	15	−25
MMBF5486	6H	2.0	100	4.0	8.0	15	−25
MMBF4416	6A	2.0	100	4.5	7.5	15	−30
MMBFJ310	6T	4.0	450	8.0	18	10	−25

TABLE 11. General-Purpose Field-Effect SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

N-CHANNEL

Device	Marking	$V_{(BR)GSS}$	Y_{fs} Min (mmhos)	Y_{fs} Max (mmhos)	Y_{fs} V_{DS} (V)	I_{DSS} Min (mA)	I_{DSS} Max (mA)
MMBF5457	6D	−25	1.0	5.0	15	1.0	5.0
BFR30	M1	−25	1.0	4.0	10	4.0	10
BFR31	M2	−25	1.5	4.5	10	1.0	5.0
MMBF5459	6L	−25	2.0	6.0	15	4.0	16
P-CHANNEL							
MMBF5460	6E	40	1.0	4.0	15	1.0	5.0

TABLE 12. Chopper/Switches, Junction Field-Effect SOT-23 Transistors

N-CHANNEL

Device	Marking	$r_{DS(on)}$ Max (Ohms)	t_{off} Max (ns)	$V_{(BR)GSS}$	$V_{(GS)\,off}$ Min (V)	$V_{(GS)\,off}$ Max (V)	I_{DSS} Min (mA)	I_{DSS} Max (mA)
MMBF4391	6J	30	20	−30	−4.0	−10	50	150
MMBF4860	6F	40	50	−30	−2.0	−6.0	20	100
MMBF4392	6K	60	35	−30	−2.0	−5.0	25	75
MMBF4393	6G	100	55	−30	−0.5	−3.0	5.0	30

MICROMINIATURE PRODUCTS (continued)

1

TABLE 13. SOT-23 Switching Diodes (Dual Unless Otherwise Noted)

Diode Pinout: Noted Below

Device	Marking	Description		t_{rr} Max (ns)	V_{BR} Min (V)	I_R Max (μA)	V_F Min (V)	V_F Max (V)	V_F @ I_F (mA)	C_{VR} Max (pF)
MMBD2836	A2	Common Anode	(5)	6(1)	75	0.1	—	1.0	10	4.0
BAW56	A1	Common Anode	(5)	6(1)	70	2.5	—	1.1	50	1.5
MMBD2835	A3	Common Anode	(5)	6(1)	35	0.1	—	1.0	10	4.0
BAV74	JA	Common Cathode	(3)	2(2)	50	0.1	—	1.0	100	2.0
MMBD2838	A6	Common Cathode	(3)	6(1)	75	0.1	—	1.0	10	4.0
BAV70	A4	Common Cathode	(3)	6(1)	70	2.5	—	1.1	50	1.5
MMBD2837	A5	Common Cathode	(3)	6(1)	35	0.1	—	1.0	10	4.0
MMBD6100	5B	Common Cathode	(3)	15(1)	70	0.1	0.85	1.1	100	2.5
MMBD914	5D	Single	(6)	4(2)	100	0.05	—	1.0	10	4.0
BAS16	A6	Single	(6)	6(1)	75	1.0	—	0.715	1.0	2.0
BAL99	TF	Single	(7)	6(1)	70	2.5	—	1.1	50	1.5
MMBD6050	5A	Single	(6)	10(1)	70	0.1	0.85	1.1	100	2.5
BAV99	A7	Series	(4)	6(1)	70	2.5	—	1.1	50	1.5
MMBD7000	5C	Series	(4)	15(1)	100	0.3	0.75	1.1	100	1.5

NOTES: (1) $I_F = I_R = 10$ mA, $V_R = 5.0$ V, $I_{RR} = 1.0$ mA
(2) $I_F = I_R = 10$ mA, $V_R = 6.0$ V, $I_{RR} = 1.0$ mA
(3) Pinout: 1-Anode, 2-Anode, 3-Cathode
(4) Pinout: 1-Anode, 2-Cathode, 3-Cathode and Anode
(5) Pinout: 1-Cathode, 2-Cathode, 3-Anode
(6) Pinout: 1-Anode, 2-N.C., 3-Cathode
(7) Pinout: 1-N.C., 2-Anode, 3-Cathode

TABLE 14. SOT-23 Tuning Diodes

Tuning Diode Pinouts: 1-Anode, 2-N.C., 3-Cathode

<table>
<tr><th rowspan="2">Device</th><th rowspan="2">Marking</th><th colspan="2">BVR</th><th colspan="3">C T</th><th colspan="2">Capacitance Ratio</th><th colspan="3">Q</th><th>RS</th><th colspan="2">VF</th><th colspan="2">IR</th></tr>
<tr><th>Min (V)</th><th>@ IR (µA)</th><th>Min (pF)</th><th>Max (pF)</th><th>@ VR (V)</th><th>Min</th><th>Max</th><th>Min</th><th>@ VR (V)</th><th>& f (MHz)</th><th>Max (ohms)</th><th>Max (V)</th><th>@ IF (mA)</th><th>Max (µA)</th><th>@ VR (V)</th></tr>
<tr><td colspan="17">TUNING DIODES</td></tr>
<tr><td>MMBV2097</td><td>4K</td><td rowspan="2">30</td><td rowspan="2">10</td><td>.8</td><td>1.2</td><td rowspan="2">4</td><td rowspan="2">2</td><td>2.6</td><td rowspan="2">325</td><td rowspan="2">4</td><td rowspan="2">100</td><td rowspan="2">—</td><td rowspan="2">—</td><td rowspan="2">—</td><td rowspan="2">.02</td><td rowspan="2">25</td></tr>
<tr><td>MMBV2098</td><td>4L</td><td>1.8</td><td>2.7</td><td>2.8</td></tr>
<tr><td>MMBV105G</td><td>4E</td><td rowspan="3">30</td><td rowspan="3">10</td><td>1.8</td><td>2.8</td><td>2.5</td><td>4</td><td>6</td><td>150</td><td>(1)</td><td>100</td><td rowspan="2">--</td><td rowspan="2">—</td><td rowspan="2">—</td><td>.05</td><td>28</td></tr>
<tr><td>MMBV2101</td><td>4G</td><td>6.1</td><td>7.5</td><td rowspan="2">4</td><td>2.5</td><td rowspan="2">3.3</td><td>450</td><td rowspan="2">4</td><td rowspan="2">50</td><td rowspan="2">.02</td><td rowspan="2">25</td></tr>
<tr><td>MMBV2103</td><td>4H</td><td>9.0</td><td>11</td><td>2.6</td><td>400</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>MMBV3102</td><td>4C</td><td>30</td><td>10</td><td>20</td><td>25</td><td>3</td><td>4.5</td><td>—</td><td>300</td><td>3</td><td>50</td><td>—</td><td>—</td><td>—</td><td>.1</td><td>25</td></tr>
<tr><td>MMBV2108</td><td>4X</td><td>30</td><td>10</td><td>24.3</td><td>29.7</td><td>4</td><td>2.7</td><td>3.3</td><td>300</td><td>4</td><td>50</td><td>—</td><td>—</td><td>—</td><td>.02</td><td>25</td></tr>
<tr><td>MMBV109</td><td>4A</td><td>30</td><td>10</td><td>26</td><td>32</td><td>.3</td><td>5</td><td>6.5</td><td>280</td><td>3</td><td>50</td><td>—</td><td>—</td><td>—</td><td>.02</td><td>25</td></tr>
<tr><td>MMBV2109</td><td>4J</td><td>30</td><td>10</td><td>29.7</td><td>36.3</td><td>4</td><td>2.7</td><td>3.3</td><td>200</td><td>4</td><td>50</td><td>—</td><td>—</td><td>—</td><td>.02</td><td>25</td></tr>
<tr><td colspan="17">"PIN" CHANNEL SWITCH</td></tr>
<tr><td>MMBV3401</td><td>4D</td><td>35</td><td>10</td><td>—</td><td>1</td><td>20</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>.7</td><td>—</td><td>—</td><td>.1</td><td>25</td></tr>
<tr><td colspan="17">HOT CARRIER DIODES</td></tr>
<tr><td>MMBD101</td><td>4M</td><td>4</td><td>10</td><td>—</td><td rowspan="3">1</td><td rowspan="2">0</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>.6</td><td rowspan="3">10</td><td rowspan="2">.25</td><td rowspan="2">3</td></tr>
<tr><td>MMBD352 (Dual)</td><td>5G</td><td>4</td><td>.25</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>.50</td></tr>
<tr><td>MMBD501</td><td>5F</td><td>50</td><td>10</td><td>—</td><td>20</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>1.2</td><td>.2</td><td>25</td></tr>
</table>

Notes: (1) Voltage such that $C_T = 9.0$ pF.

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MICROMINIATURE PRODUCTS (continued)

TABLE 15. SOT-23 Zener Diodes

Pinout 1-Anode, 2-N.C., 3-Cathode (Tolerance ± 5%)

VZ (Nom) Volts	U.S. Standards	Device Marking	Pro-Electron Equivalent	Device Marking
3.3	MMBZ5226	8A		
3.6	MMBZ5227	8B		
3.9	MMBZ5228	8C		
4.3	MMBZ5229	8D		
4.7	MMBZ5230	8E	BZX84C4V7	Z1
5.1	MMBZ5231	8F	BZX84C5V1	Z2
5.6	MMBZ5232	8G	BZX84C5V6	Z3
6.0	MMBZ5233	8H		
6.2	MMBZ5234	8J	BZX84C6V2	Z4
6.8	MMBZ5235	8K	BZX84C6V8	Z5
7.5	MMBZ5236	8L	BZX84C7V5	Z6
8.2	MMBZ5237	8M	BZX84C8V2	Z7
8.7	MMBZ5238	8N		
9.1	MMBZ5239	8P	BZX84C9V1	Z8
10.0	MMBZ5240	8Q	BZX84C10	Z9
11.0	MMBZ5241	8R	BZX84C11	Y1
12.0	MMBZ5242	8S	BZX84C12	Y2
13.0	MMBZ5243	8T	BZX84C13	Y3
14.0	MMBZ5244	8U		
15.0	MMBZ5245	8V	BZX84C15	Y4
16.0	MMBZ5246	8W	BZX84C16	Y5
17.0	MMBZ5247	8X		
18.0	MMBZ5248	8Y	BZX84C18	Y6
19.0	MMBZ5249	8Z		
20.0	MMBZ5250	81A	BZX84C20	Y7
22.0	MMBZ5251	81B	BZX84C22	Y8
24.0	MMBZ5252	81C	BZX84C24	Y9
25.0	MMBZ5253	81D		
27.0	MMBZ5254	81E	BZX84C27	Y10
28.0	MMBZ5255	81F		
30.0	MMBZ5256	81G	BZX84C30	Y11
33.0	MMBZ5257	81H	BZX84C33	Y12

TABLE 16. SOT-23 Silicon Controlled Rectifier

Rectifier Pinouts: 1-Cathode, 2-Gate, 3-Anode

Device	Marking	I_F (mA)	V_{FXM} (mA)	I_{GT} (μA)	V_{GT} (V)	I_H (mA)
MMBS5062	5T	500	100	200	.8	5
MMBS5061	5S	500	50	200	.8	5
MMBS5060	5R	500	25	200	.8	5

MICROMINIATURE PRODUCTS (continued)

TABLE 17. SOT-23 Silicon Programmable Unijunction Transistors

Transistor Pinouts: 1-Cathode, 2-Gate, 3-Anode

Device	Marking	I_{TRM} (Amp) (1)	I_{TSM} (Amp) (2)	Max (μA) I_P (3)	Min (V) V_T	Max (V)	Max (μA) I_V (3)	Max (V) V_F
MMBPU131	5Z	1	1	2	.2	.7	50	1.5

NOTES:

1. Repetitive Peak Forward Current
   100 μs Pulse Width
   1.0% Duty Cycle
2. Non-Repetitive Peak Forward Current
   10 μs Pulse Width
3. V_S = 10 Vdc, R_G = 1.0 mΩ

TABLE 18. SOT-89 Transistors

Pinout: 1-Base, 2-Collector, 3-Emitter

General Purpose

NPN

Device	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
BCX56	80	40	160	150	50
BCX55	60	40	160	150	50
BCX54	45	40	250	150	50
MXT3904	40	100	300	10	300
BCX68	20	85	375	500	65

PNP

BCX53	80	40	160	150	50
BCX52	60	40	160	150	50
BCX51	45	40	250	150	50
MXT3906	40	100	300	10	250
BCX69	20	85	375	500	65

High Voltage

NPN

MXTA44	400	50	200	10	—
MXTA42	300	40	—	10	50
MXTA43	200	50	200	30	—

PNP

MXTA92	300	40	—	10	50
MXTA93	200	30	150	30	50

Darlingtons

Device	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	$V_{BR(CBO)}$	$V_{CE(sat)}$ Max (V)
NPN					
MXTA27	10 K	—	10	60	1.5
MXTA14	10 K	—	10	30	1.5
PNP					
MXTA77	10 K	—	10	60	1.5

MICROMINIATURE PRODUCTS (continued)

TABLE 18. SOT-89 Transistors (continued)

Pinout: 1-Base, 2-Collector, 3-Emitter

RF

NPN

Device	f_T Min (MHz)	f_T I_C (mA)	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} I_C (mA)
BFQ19	4000	50	15	25	—	50
BFQ18A	3200*	—	15	25	—	50
MXR5943	1200	50	30	25	300	50
BFQ17	1200	150	25	25	—	50
MR3866	500	50	30	10	200	50

PNP

Device	f_T Min (MHz)	f_T I_C (mA)	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} I_C (mA)
MXR5583	1000	40	30	25	100	100
MXR5160	500	50	40	10	—	50

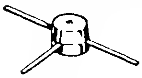
*Typ

Micro-T Transistors

Micro-T devices combine high performance with extremely small physical size. The devices shown in these tables are available from stock; all other Motorola small-signal transistors may be obtained in Micro-T packages on special order.

GENERAL-PURPOSE AND SWITCHING TRANSISTORS

For general-purpose applications and for designs requiring fast switching. Complete data sheets are available for prime devices; equivalent data sheets may be obtained when the same die is used in other 2N—standard devices. For devices not listed, contact your nearest Motorola representative or distributor. Ceramic packages with a cold sealing process are also available on demand.



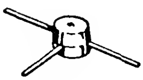
Case 28

Package		NPN Types		PNP Type
Plastic	**MMT2222**	**MMT3904**	**MMT2369**	**MMT2907**
Ceramic	**MMCM2222**	**MMCM3904**	**MMCM2369**	**MMCM2907**
Design Parameters				
BV_{CEO}	To 60 V	To 40 V	To 15 V	To 60 V
Operating h_{FE} Range	100μA to 500 mA	100μA to 100 mA	10 mA to 100 mA	100 μA to 500 mA
f_T (Typ)	300 MHz 20 mA	300 MHz 10 mA	650 MHz 10 mA	350 MHz 50 mA
t_{on} (Typ)	25 ns	40 ns	2.0 ns	30 ns
	150 mA	10 mA	10 mA	150 mA
t_{off} (Typ)	250 ns	140 ns	15 ns	100 ns

RF AMPLIFIER

Standard RF devices in Micro-T packages are designed for applications where limited space is critical. This package is particularly attractive from a pre-testing and cost point of view as the RF parameters can be 100% tested for high performance. For complete design data, consult the prime device data sheet. For other devices not listed, contact your nearest Motorola sales representative or distributor. Ceramic packages with a cold sealing process are also available on demand.

Package	NPN Type
Plastic	**MMT918**
Ceramic	**MMCM918**
BV_{CEO}	15 V
Operating h_{FE} Range	3.0 mA
f_T (Typ)	600 MHz 4.0 mA
NF (Typ)	6.0 dB 1.0 mA
G_{pe} (Typ)	15 dB 200 MHz
t_{on} (Typ)	



Case 28

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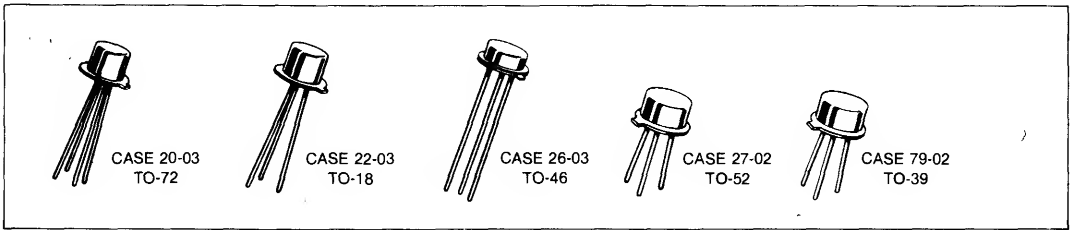
Metal Small-Signal Transistors



Motorola Small-Signal Metal Can Transistors are designed for use as General-Purpose Amplifiers, High-Speed Switches, High-Voltage Amplifiers, Low-Level/Low-Noise Amplifiers, High-Frequency Oscillators, Choppers, and Darlingtons. These devices are manufactured in a variety of packages, i.e., TO-18, TO-39, TO-46, TO-52, and TO-72.

The following selector guide tables also indicate those Motorola small-signal metal can transistors which are qualified under CECC 50000, and MIL-19500 high-rel requirements. Devices are available to CECC Levels L, F and E (see qualified products Table page 26). JAN, JANTX, JANTXV and JANS versions as specified.

TABLE 1. Switching Transistors

The following devices are intended for use in general-purpose switching and amplifier applications. Within each package group shown, the devices are listed in order of decreasing turn-on time (t_{on}).

Package	Device Type	t_{on} ns Max	& t_{off} ns Max	@ I_C mA	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} Min	@ I_C mA	$V_{CE(sat)}$ Volts Max	@ I_C mA	@ I_B mA	f_T MHz Min	I_C mA	Comments
NPN														
TO-18	2N4014	35	60	500	50	1000	35	500	0.52	500	50	300	50	
	2N2369	12	18	100	15	500	20	100	0.25	10	1.0	500	10	Exists under CECC
	2N2369A†	12	18	10	15	200	40	10	0.2	10	1.0	500	10	Exists under CECC
	2N3227	12	18	100	20	50	30	100	0.25	10	1.0	500	10	
	BSX20	7	18	100	15	500	20	10	0.25	10	1.0	400	10	
TO-39	2N3735#	48	60	1000	50	1500	20	1000	0.5	500	50	250	50	
	2N3506#	45	90	1500	40	3000	40	1500	1.0	1500	150	60	100	
	BSX60	40	70	500	30	1000	30	500	0.5	500	50	—	—	
	2N3725	35	60	500	50	2000	35	500	0.52	500	50	300	50	
	BSX59	35	60	500	45	1000	25	500	0.5	500	50	—	—	
	2N3724	35	60	500	30	2000	35	500	0.42	500	50	300	50	
	2N3303	15	25	1000	—	1000	20	10	0.7	1000	100	450	100	
TO-46	2N3737#	48	60	1000	50	1500	20	1000	0.5	500	50	250	50	
	2N3647	20	25	150	10	500	25	150	0.4	150	15	350	15	
	2N3509	12	18	10	20	500	100	10	0.25	10	1.0	500	10	
PNP														
TO-18	2N2894	60	90	30	12	200	40	30	0.2	30	3.0	400	30	
	2N3546	40	30	50	12		25	50	0.25	50	5.0	700	10	
	2N4208	15	20	10	12	200	30	10	0.15	10	1.0	700	10	
	2N4209	15	20	10	15	50	40	50	0.6	50	5.0	850	10	
TO-39	2N3635#	400	600	50	140	1000	100	50	0.5	50	5.0	200	30	
	2N3636#	400	600	50	175	1000	50	50	0.5	50	5.0	150	30	
	2N4036	110	700	150	65	1000	40	150	0.65	150	15	60	50	
	2N4033#	100	240 (typ)	500	80	1000	25	1000	0.5	500	50	150	50	
	2N4407	75	225	1000	80	1500	30	1000	0.7	1000	100	150	50	
	2N3244	50	185	500	40	1000	50	500	0.5	500	50	175	50	
	2N3467#	40	90	500	40	100	40	500	0.5	500	50	175	50	
	2N3762#	43	115	1000	40	1500	30	1000	0.9	1000	100	180	50	
	2N4405**	40	210	500	80	1000	50	500	0.5	500	50	200	50	

*JAN available **JAN/JANTX available †JAN/JANTX/JANTXV/JANS available # JAN/JANTX/JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

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TABLE 2. Darlington Transistors

These transistors are characterized for very high gain and input impedance applications. Devices are of monolithic construction.

Package	Device Type	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} Min	h_{FE} Max	@ I_C mA	$V_{CE(sat)}$ Volts Max	@ I_C mA	& I_B mA
NPN									
TO-18	MM6427	40	300	5000		10	1.5	100	0.1
TO-39	BSS52	80	1000	2000	—	500	1.6	1000	4.0
	BSS51	60	1000	2000	—	500	1.6	1000	1.0
	BSS50	45	1000	2000	—	500	1.6	1000	4.0
PNP									
TO-39	BSS62	80	1000	2000	—	500	1.8	1000	4.0
	BSS61	60	1000	2000	—	500	1.8	1000	1.0
	BSS60	45	1000	2000	—	500	1.8	1000	4.0

TABLE 3. High-Frequency Amplifiers/Oscillators

The transistors shown are designed for use as both oscillators and amplifiers at UHF and VHF frequencies. Devices are listed in decreasing order of $V_{(BR)CEO}$ with each line.

Package	Device Type	$V_{(BR)CEO}$ Volts Min	h_{FE} Min	@ I_C mA	G_{pe} dB Min	NF dB Max	@ f MHz	f_T MHz Min	@ I_C mA	C_{obo} pF Max
NPN										
TO-72	2N918†	15	20	3.0	15	6.0	60	600	4.0	1.7
PNP										
TO-72	2N4261#	15	30	10	—	—	—	1600	10	2.5

*JAN available **JAN/JANTX available †JAN/JANTX/JANTXV/JANS available #JAN/JANTX/JANTXV available

TABLE 4. High-Voltage/High-Current Amplifiers

The following table lists Motorola standard devices that have high Collector-Emitter Breakdown Voltage. Devices are listed in decreasing order of $V_{(BR)CEO}$ within each package type.

Package	Device Type	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} Min	@ I_C mA	$V_{CE(sat)}$ Volts Max	@ I_C mA	& I_B mA	f_T MHz Min	@ I_C mA	Comments
NPN											
TO-18	BSS73	300	500	40	30	0.5	50	5	100	20	
	BSS72	250	500	40	30	0.5	50	5	100	20	
	BSS71	200	500	40	30	0.5	50	5	100	20	
	BC394	180	500	30	10	0.3	10	1.0	50	20	
TO-39	2N3439#	350	1000	40	20	0.5	50	4	15	10	Exists under CECC
	MM421	325	1000	25	30	5.0	30	3	15	10	
	BF259	300	100	25	30	1.0	30	6	110	30	
	BF258	250	100	25	30	1.0	30	6	110	30	
	2N3440#	250	1000	40	20	0.5	50	4	15	10	Exists under CECC
	BSS78	250	500	40	30	0.4	30	3	70	20	
	BF337	200	200	20	30	—	—	—	80	30	
	BSS77	200	500	40	30	0.4	30	3	70	20	

JAN JANTX, JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 4. High-Voltage/High-Current Amplifiers (continued)

The following table lists Motorola standard devices that have high Collector-Emitter Breakdown Voltage. Devices are listed in decreasing order of $V_{(BR)CEO}$ within each package type.

Package	Device Type	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} Min	@ I_C mA	$V_{CE(sat)}$ Volts Max	@ I_C mA	& I_B mA	f_T MHz Min	@ I_C mA	Comments
NPN											
TO-39	BUY49S	200	3000	40	500	0.2	500	50	—	—	
	BF257	160	100	25	30	1.0	30	6	110	30	
	BSW68A	150	2000	30	500	1.0	500	150	—	—	
	2N3114	150	200	30	30	1.0	50	5.0	40	30	
	2N3501#	150	300	100	150	0.4	150	15	150	20	
	BSW67A	120	2000	30	500	1.0	500	150	—	—	
	2N5682	120	1000	40	250	0.6	250	25	30	100	
	2N4924	100	200	40	150	0.4	50	5.0	100	20	
	MM3007	100	2500	50	250	0.35	150	15	50	50	
	2N5681	100	1000	40	250	0.6	250	25	30	100	
	2N4239	80	3000	30	250	0.3	500	50	2	100	
	MM3005	60	2500	50	150	0.35	150	15	50	50	
	2N4237	40	3000	30	250	0.3	500	50	2	100	
PNP											
TO-18	BSS76	300	500	35	30	0.5	50	5.0	100	20	
	BSS75	250	500	35	30	0.5	50	5.0	100	20	
	BSS74	200	500	35	30	0.5	50	5.0	100	20	
	BC393	180	500	50	10	0.3	10	1.0	50	20	
	2N3497	120	100	40	10	0.35	10	1.0	150	20	
TO-39	2N5416#	300	1000	30	50	2.5	50	5	15	10	Exists under CECC
	MM4003	250	500	20	10	5.0	10	1.0	—	—	
	2N5415#	200	1000	30	50	2.5	50	5	15	10	Exists under CECC
	2N3637#	175	1000	100	50	0.5	50	5.0	200	30	
	2N3636#	175	1000	50	50	0.5	50	5.0	150	30	
	MM4001	150	500	20	10	0.6	10	1.0	—	—	
	2N3635#	140	1000	100	50	0.5	50	5.0	200	30	
	2N3634#	140	1000	50	50	0.5	50	5.0	150	30	
	2N3495	120	100	40	10	0.35	10	1.0	150	20	
	2N5680	120	1000	40	250	0.6	250	15	30	100	
	MM4000	100	100	20	10	0.6	10	1.0	—	—	
	MM5007	100	2000	50	250	0.5	150	15	30	50	
	2N5679	100	1000	40	250	0.6	250	25	30	100	
	2N5679	100	1000	40	250	0.6	250	25	30	100	
	2N4236	80	3000	30	250	0.6	1000	125	3	100	
	2N4036	65	1000	40	150	0.65	150	15	60	50	
	MM5005	60	2000	50	150	0.5	150	15	30	50	
	2N4235	60	3000	30	250	0.6	1000	125	3	100	
	2N4234	40	3000	30	250	0.6	1000	125	3	100	

JAN, JANTX, JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 5. General-Purpose Amplifiers

These transistors are designed for dc to VHF amplifier applications, general-purpose switching applications, and complementary circuitry. Devices are listed in decreasing order of $V_{(BR)CEO}$ within each package group.

Package	Device Type	$V_{(BR)CEO}$ Volts Min	f_T MHz Min	@ I_C mA	I_C mA Max	h_{FE} Min	h_{FE} Max	@ I_C mA	Comments
NPN									
TO-18	2N2896	90	120	50	1000	60	200	150	
	2N3700#	80	80	1.0	1000	50		500	
	2N2484#	60	15	0.05	50	100	500	0.01	Exists under CECC
	2N930	45	30	0.5	30	100	300	0.01	
	BCY59	45	125	10	200	120	630	2	Exists in VII, VIII, IX, X HFE groups
	BC107	45	150	10	100	110	800	2	Exists under CECC A, B HFE groups
	2N2222A#	40	300	20	800	100	300	150	Exists under CECC
	BCY58	32	125	10	200	120	630	2	Exists in VII, VIII, IX, X HFE groups
	2N2222#	30	250	20	800	100	300	150	Exists under CECC
	BSX51	25	150	10	200	75	225	2	
	BSX52	25	150	10	200	180	540	2	
	BC108	20	150	10	100	110	800	2	Exists under CECC A, B, C, HFE groups
	BC109	20	150	10	100	200	800	2	Exists under CECC B, C, HFE groups
TO-39	BSX47	80	50	50	1000	40	400	150	Exists in -6, -10, -16 HFE groups
	2N1711	80	70	50		100	300	150	Exists under CECC
	2N3019#	80	100	50	1000	100	300	150	
	BSX46	60	50	50	1000	40	250	100	Exists in -6, -10, -16 HFE groups
	BC141	60	50	50	1000	40	400	100	Exists in -6, -10, -16 HFE groups
	2N1613#	50	60	50	500	40	120	150	Exists under CECC
	BSX45	40	50	50	1000	40	250	100	Exists in -6, -10, -16 HFE groups
	BC140	40	50	50	1000	40	400	100	Exists in -6, -10, -16 HFE groups
	2N2219A#	40	300	20	800	100	300	150	Exists under CECC
	2N3053	40	100	50	700	50	250	150	
	BFY50	35	60	50	1000	30	—	150	
	BFY51	30	50	50	1000	40	—	150	
	2N2219#	30	250	20	800	100	300	150	Exists under CECC
	BFY52	20	50	50	1000	50	—	150	

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 5. General-Purpose Amplifiers (continued)

Package	Device Type	$V_{(BR)CEO}$ Volts Min	f_T MHz Min	@ I_C mA	I_C mA Max	h_{FE} Min	h_{FE} Max	@ I_C mA	Comments
PNP									
TO-18	2N3963	80	40	0.5	200	100	450	0.01	
	2N4026	80	100	50	1000	15	—	100	
	2N4029	80	150	50	1000	25	—	100	
	2N3799	60	30	0.5	50	300	900	0.5	
	2N2906A#	60	200	50	600	40	120	150	Exists under CECC
	2N2907A†	60	200	50	600	100	300	150	Exists under CECC
	2N3964	45	50	0.5	200	250	600	0.01	
	BC177	45	130	10	100	70	500	2	Exists in A, B, C HFE groups
	BCY79	45	180*	10	200	120	630	2	Exists In VII, VIII, IX, X HFE groups
	BCY71	45	200	10	200	100	600	10	
	2N2906#	40	200	50	600	40	120	150	Exists under CECC
	2N2907#	40	200	50	600	100	300	150	Exists under CECC
	BCY70	40	250	10	200	50	—	10	
	2N3251	40	300	10	200	100	300	10	
	BCY78	32	180*	10	200	120	630	2	Exists in VII, VIII, IX, X HFE groups
	BC178	30	130	10	100	70	800	2	Exists in A, B, C HFE groups
	BCY72	25	200	10	200	50	—	10	
	BC179	20	130	10	100	120	800	2	Exists in A, B, C HFE groups
TO-39	MM5007	100	30	50	2000	50	250	250	
	BSV17	80	50	50	1000	40	160	100	Exist en -6, -10 HFE groups
	2N4033#	80	150	50	1000	25	—	100	
	2N4405**	80	200	50	1000	100	300	150	
	BFX41	75	100	50	1000	40	—	100	
	BFX40	75	100	50	1000	85	—	100	
	2N4036	65	60	50	1000	40	140	150	
	BSV16	60	50	50	1000	40	250	100	Exists in -6, -10, -16 HFE groups
	BC161	60	50	50	1000	40	400	100	Exists in -6, -10, -16 HFE groups
	2N2904A#	60	200	50	600	40	120	150	Exists under CECC
	2N2905A†	60	200	50	600	100	300	150	Exists under CECC
	BC160	40	50	50	1000	40	400	100	Exists in -6, -10, -16, HFE groups
	BSV15	40	50	50	1000	40	250	100	Exists in -6, -10, -16 HFE groups
	2N2904#	40	200	50	600	40	120	150	Exists under CECC
	2N2905#	40	200	50	600	100	300	150	Exists under CECC
TO-46	2N2605#	45	30	0.5	30	100	300	0.01	
	2N3486	40	200	50	600	100	300	150	

* JAN available ** JAN/JANTX available # JAN/JANTX/JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 6. Choppers

Devices are listed in decreasing $V_{(BR)EBO}$.

Package	Device	$V_{(BR)EBO}$ Min	$V_{(BR)ECO}$	Min $h_{FE(inv)}$	Offset Voltage $V_{EC(ofs)}$ Max (mV)	On-State Resistance $r_{ec(on)}$ Max (Ω)
TO-46	2N2946	40	35	3.0	2.0	45
	2N2946A	40	35	20	2.0	8.0
	2N5230	30	20	15	0.5	8.0
	2N5231	30	20	15	0.8	10
	2N2945A	25	20	30	1.0	6.0
	2N2945	25	20	4.0	1.0	35
	2N5229	15	10	15	0.5	6.0

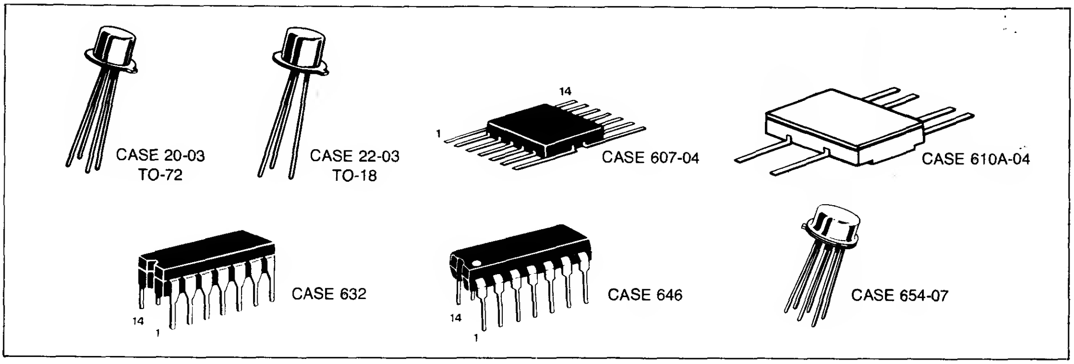
JAN/JANTX available

TABLE 7. CECC Qualified Types

Qualified products to CECC 50000
All CECC types are available to assessment levels E, F, L

2N1613 (CECC)	2N2369 (CECC)	2N3440 (CECC)
2N1711 (CECC)	2N2369A (CECC)	2N5415 (CECC)
2N1893 (CECC)	2N2484 (CECC)	2N5416 (CECC)
2N2218 (CECC)	2N2904 (CECC)	BC107-108-109 (CECC)
2N2218A (CECC)	2N2904A (CECC)	CV8616 (CECC)
2N2219 (CECC)	2N2905 (CECC)	CV9507 (CECC)
2N2219A (CECC)	2N2905A (CECC)	CV9543 (CECC)
2N2221 (CECC)	2N2906 (CECC)	PO7726 (CECC)
2N2221A (CECC)	2N2906A (CECC)	
2N2222 (CECC)	2N2907 (CECC)	
2N2222A (CECC)	2N2907A (CECC)	
2N2368 (UTE)	2N3439 (CECC)	

Multiple Small-Signal Transistors



The trend in electronic system design is toward the use of integrated circuits — to reduce component cost, assembly cost, and equipment cost. But ICs still aren't all things to all people, and for those circuit designs where ICs are not available, there is a noticeable swing towards the use of multiple devices.*

Motorola is reacting to this expanding market requirement by making available a large selection of Quad, Dual, and Darlington transistors for off-the-shelf delivery. The chips used in the Quad and Dual transistors are those that have emerged as the most popular ones for discrete transistor applications. But even beyond that, Motorola offers its entire vast repertoire of discrete small-signal transistors for multiple-device packaging. For special applications where the devices in this brochure might not quite fit the design requirements, special configurations can be supplied with quick turnaround time and at low premiums.

**Multiple devices, as described here, encompass two or more transistor chips in a single package. Included in this definition are the Darlington transistors which consist of two interconnected devices functioning as a single-stage amplifier.*

Specification Tables

The following short form specifications include Quad and Dual transistors listed in alphanumeric order. Some columns denote two different types of data indicated by either **bold** or *italic* typeface. See key and headings for proper identification.

KEY

TYPE NO	ID	P_D Watts One Die Only	Ref Point	V_{CE}- Volts	Subscript	I_C Amp Max	h_{FE} @ I_C Min	Unit	f_T MHz Min	C_{ob} pF Max	**h_{FE1}/h_{FE2}** / *t_{on} ns Max*	**ΔV_{BE} mV Max** / *t_{off} ns Max*	**Gp dB Min / NF dB Max @ f** / *V_{CE}(sat) @ — & I_C Volts Max / I_C / I_B*	Unit	PACKAGE TO-No. / Case No.

Alphanumeric listing type numbers

Identification Code
1st Letter: Polarity
C – both types in multiple device
N – NPN
P – PNP
2nd Letter, Use
A – General Purpose Amplifier
E – Low Noise Audio Amplifier
F – Low Noise RF Amplifier
G – General Purpose Amplifier and Switch
H – Tuned RF/IF Amplifier
M – Differential Amplifier
S – High Speed Switch

Power Dissipation specified at 25°C Single die rating
Ref. Point: A Ambient temperature; C Case temperature

Rated maximum Collector Emitter Voltage
Subscript letter identifies base termination listed below in order of preference
SUBSCRIPT
O V_{CEO}, open

Continuous (DC) Collector Current

Common emitter DC Current Gain

Units for test current
A ampere
m mA
u μA

Current Gain Bandwidth Product

Output Capacitance, common-base. Shown without distinction.
C_{cb} Collector Base Capacitance
C_{re} – Common Emitter Reverse Transfer Capacitance

h_{FE1}/h_{FE2} – Current Gain Ratio
V_{BE} – Differential Base Voltage $|V_{BE1} - V_{BE2}|$.
Differential Amplifiers
t_{on} turn-on time
t_{off} turn-off time

G_p – Power Gain
NF – Noise Figure
f – Test Frequency
AUD – 10-15k Hz
Frequency Units:
H - Hertz
K kHz
M MHz
G GHz
$V_{CE(sat)}$ Collector-Emitter Saturation Voltage
I_C Test Current
Current Units
u μA
m mA
A Amp

JEDEC Outline/ Motorola Package Outline

MULTIPLE SMALL-SIGNAL TRANSISTORS (continued)

TABLE 1. Quad Transistors

TYPE NO.	ID	P_D Watts One Die Only	Ref. Point	V_{CE} Volts	Subscript	I_C Amp Max	h_{FE} Min	@ I_C	Unit	f_T MHz Min Typ*	C_{ob} pF Max Typ*	h_{FE1}/h_{FE2} / *t_{on} ns Max Typ**	ΔV_{BE} mV Max / *t_{off} ns Max Typ**	Gp dB Min / *V_{CE} (sat) @ Volts Max*	NF dB Max Typ* / *I_C/I_B*	@ f / *I_C*	Unit	PACKAGE TO- No.	Case No.
MHQ918	NF	0.65 A		15	○	0.05	20	3.0 m		600	2.0				**6.0**	**60 M**		116	632
MHQ2222	NG	0.65 A		40	○	0.5	100	150 m		200	8.0	*25**	*250**	*.4*	*10*	*150 m*		116	632
MHQ2369	NS	0.5 A		15	○	0.5	40	10 m		450	4.0	*9.0**	*15**	*.25*	*10*	*10 m*		116	632
MHQ2484	NA	0.6 A		40	○	0.05	300	1.0 m		50					**2***	**AUD**		116	632
MHQ2907	PG	0.65 A		40	○	0.6	100	150 m		200	8.0	*30**	*100**	*.4*	*10*	*150 m*		116	632
MHQ3467	PS	0.9 A		40	○	1.0	20	500 m		125	25	*40*	*90*	*.5*	*10*	*500 m*		116	632
MHQ3546	PS	0.5 A		12	○	0.2	30	10 m		600	6.0	*15**	*25**	*.25*	*10*	*10 m*		116	632
MHQ3799	PA	0.5 A		60	○	0.05	300	0.1 m		60	4.0				**2***	**AUD**		116	632
MHQ4014	NS	0.75 A		45	○	1.5	35	500 m		200	10	*35*	*60*	*.52*	*10*	*500 m*		116	632
MHQ6001	CA	0.65 A		30	○	0.5	40	150 m		200	8.0	*30**	*225**	*.4*	*10*	*150 m*		116	632
MHQ6002	CA	0.65 A		30	○	0.5	100	150 m		200	8.0	*30**	*225**	*.4*	*10*	*150 m*		116	632
MHQ6100	CA	0.5 A		40	○	0.05	75	1.0 m		175*	4.5*			*.25*		*1.0 m*		116	632
MPQ918	NA	0.625 A		15	○	0.05	20	3.0 m		600	1.7				**6.0**	**60 M**			646
MPQ2222	NA	0.65 A		30	○	0.5	100	150 m		200	8.0	*25**	*250**	*.4*	*10*	*150 m*			646
MPQ2369	NS	0.5 A		15	○	0.5	40	10 m		450	4.0	*9.0**	*15**	*.25*	*10*	*10 m*			646
MPQ2484	NA	0.625 A		40	○	0.05	300	1.0 m		50					**2***	**AUD**			646
MPQ2907	PA	0.65 A		40	○	0.6	100	150 m		200	8.0	*30**	*100**	*.4*	*10*	*150 m*			646
MPQ3467	PS	0.75 A		40	○	1.0	20	500 m		125	25	*40*	*90*	*0.5*	*10*	*500 m*			646
MPQ3546	PA	0.5 A		12	○	0.2	30	10 m		600	6.0	*15**	*25**	*.25*	*10*	*10 m*			646
MPQ3725	NS	1.0 A		40	○	1.0	25	500 m		250	10	*35*	*60*	*.45*	*10*	*500 m*			646
MPQ3762	PS	0.75 A		40	○	1.5	35	150 m		150	15	*50*	*120*	*.55*	*10*	*500 m*			646
MPQ3799	PA	0.625 A		60	○	0.05	300	0.1 m		60	4.0				**2***	**AUD**			646
MPQ3904	NG	0.50 A		40	○	0.2	75	10 m		250	4.0	*37**	*136**	*0.2*	*10*	*10 m*			646
MPQ3906	PG	0.50 A		40	○	0.2	75	10 m		200	4.5	*43**	*155**	*.25*	*10*	*10 m*			646
MPQ6001	CG	0.65 A		30	○	0.5	40	150 m		200	8.0	*30**	*225**	*0.4*	*10*	*150 m*			646
MPQ6002	CG	0.65 A		30	○	0.5	100	150 m		200	8.0	*30**	*225**	*0.4*	*10*	*150 m*			646
MPQ6100	CA	0.5 A		40	○	0.05	75	1.0 m		50	4.0				**4***	**AUD**			646
MPQ6501	CG	0.65 A		30	○	0.5	40	150 m		200	8.0	*30**	*225**	*0.4*	*10*	*150 m*			646
MPQ6502	CG	0.65 A		30	○	0.5	100	150 m		200	8.0	*30**	*225**	*0.4*	*10*	*150 m*			646
MPQ6600	CA	0.5 A		40	○	0.05	75	1.0 m		50	4.0				**4***	**AUD**			646
MPQ6842	CA	0.75 A		40	○	0.5	70	10 m		300	4.5	*45*	*150*	*0.15*	*10*	*0.5 m*			646
MPQ7042	NA	0.75 A		200	○	0.5	25	1.0 m		50	5.0			*0.5*	*10*	*20 m*			646
MPQ7043	NA	0.75 A		250	○	0.5	25	1.0 m		50	5.0			*0.5*	*10*	*20 m*			646
MPQ7052	CA	0.75 A		200	○	0.5	25	1.0 m		50	5.0			*0.7*	*10*	*20 m*			646
MPQ7053	CA	0.75 A		250	○	0.5	25	1.0 m		50	5.0			*0.7*	*10*	*20 m*			646
MPQ7092	PA	0.75 A		200	○	0.5	25	1.0 m		50	5.0			*0.5*	*10*	*20 m*			646
MPQ7093	PA	0.75 A		250	○	0.5	35	10 m		50	5.0			*0.5*	*10*	*20 m*			646
MQ918	NA	0.55 A		15	○	0.05	50	3.0 m		600	1.7				**6.0**	**60 M**			607
MQ2219	NA	0.6 A		30	○	0.5	100	150 m		200	8.0			*0.3*	*10*	*150 m*			607
MQ2369	NS	0.40 A		15	○	0.5	40	10 m		500	4.0	*15*	*20*	*.25*	*10*	*10 m*			607
MQ2484	NE	0.4 A		60	○	0.03	100	10 u		260*	6.0				**3.0**	**AUD**			607
MQ2905A	PG	0.4 A		60	○	0.6	100	150 m		300	8.0	*42*	*130*	*.4*	*10*	*150 m*			607
MQ3251	PA	0.40 A		40	○	0.05	100	10 m		300	6.0			*.25*	*10*	*10 m*			607
MQ3467	PS	0.40 A		40	○	1.0	20	500 m		150	20	*40*	*110*	*0.5*	*10*	*500 m*			607
MQ3725	NS	0.40 A		40	○	1.0	50	100 m		200	10	*45*	*75*	*.26*	*10*	*100 m*			607
MQ3762	PS	0.40 A		40	○	1.5	20	1.0 A		150	20	*40*	*110*	*1.0*	*10*	*1.0 A*			607
MQ3799	PA	0.40 A		60	○	0.05	300	100 u		450*	4.0			*0.2*	*10*	*1.0 m*			607
MQ6001	CG	0.40 A		30	○	0.5	40	150 m		200	8.0	*60*	*350*	*0.4*	*10*	*150 m*			607
MQ6002	CG	0.40 A		30	○	0.5	100	150 m		200	8.0	*60*	*350*	*0.4*	*10*	*150 m*			607
MQ7001	PA	0.4 A		30	○	0.6	70	1.0 m		200	8.0			*0.4*	*10*	*150 m*			607
MQ7003	NA	0.40 A		40	○	0.05	50	10 m		200	6.0			*.35*	*10*	*1.0 m*			607
MQ7021	CG	0.40 A		40	○	0.05	50	10 m		200	6.0	*28**	*72**	*.35*	*10*	*10 m*			607
2N5146	PA	0.4 A		40	○	1.5	20	1.0 A		150	20	*40*	*110*	*1.0*	*10*	*1.0 A*			607
2N6501	NS	0.6 A		40	○	1.0	50	100 m		250	10	*35*	*60*	*0.3*	*10*	*100 m*			607

Some columns show 2 different types of data indicated by either **bold** *or italic typefaces. See key and headings.*

MULTIPLE SMALL-SIGNAL TRANSISTORS (continued)

TABLE 2. Quad TMOS Fets (N Channel)

Device	$r_{ds(on)}$ (Ω) Max	@ I_D (A)	$V_{GS(t/h)}$ (V) Min	Max	@ V_{DS} (V)	I_D (mA)	I_{DSS} (µA) Max	@ V_{DS} (V)	$V_{(BR)DSS}$ (V) Min	@ I_D (µA)	I_{GSS} (nA) Max	@ V_{GS} (V)	C_{iss} (pF) Max	@ V_{DS} (V)	C_{rss} (pF) Max	@ V_{DS} (V)	t_{on} (ns) Max	t_{off} (ns) Max
MFQ930C	1.4	1.0	1.0	3.5	V_{GS}	1.0	10	35	35	10	50	15	70	25	18	25	15	15
MFQ960C	1.7	1.0	1.0	3.5	V_{GS}	1.0	10	60	60	10	50	15	70	25	18	25	15	15
MFQ990C	2.0	1.0	1.0	3.5	V_{GS}	1.0	10	90	90	10	50	15	70	25	18	25	15	15
MFQ107	14	0.2	1.0	4.0	V_{GS}	1.0	10	200	200	10	50	15	90	25	3.5	25	15	15
MFQ170	5	0.2	0.8	3.0	V_{GS}	1.0	0.5	25	60	10	10	15	70	25	18	25	10	10

TABLE 3. Dual Transistors

TYPE NO.	ID	P_D Watts One Die Only / Ref. Point	V_{CE} Volts / Subscript	I_C Amp Max	h_{FE} Min	@ I_C / Unit	f_T MHz Min	C_{ob} pF Max	**h_{FE1}/h_{FE2}** / *t_{on} ns Max*	**ΔV_{BE} mV Max** / *t_{off} ns Max*	**Gp dB Min** / *$V_{CE(sat)}$ Volts Max*	**NF dB Max** / @ *I_C/I_B*	@ f & I_C / Unit	PACKAGE TO- No.	Case No.
BFX11	PM	0.4 A	45 ○	0.05	80	50 m	130	8.0	0.8	5.0	0.25	20	50 m	78	654
BFX15	NM	0.5 A	40 ○	0.5	60	100 u	50	15	0.9	5.0	1.0	10	1.0 m	78	654
BFX36	PM	0.4 A	60 ○	0.05	100	10 u	40	6.0	0.9	3.0	0.25	20	10 m	78	654
BFY81	NM	0.4 A	45 ○	0.03	100	100 u	60	6.0	0.8	10	0.35	10	1.0 m	78	654
MD918	NF	0.55 A	15 ○	0.05	50	3.0 m	600	1.7				**6.0**	**60 M**		654
MD918A	NM	0.55 A	15 ○	0.05	50	3.0 m	600	1.7	**0.9**	**5.0**		**6.0**	**60 M**		654
MD918AF	NM	0.35 A	15 ○	0.05	50	3.0 m	600	1.7	**0.9**	**5.0**		**6.0**	**60 M**		610A
MD2219	NG	0.575 A	30 ○	0.5	100	150 m	200	8.0	*60*	*350*	*0.4*	*10*	*150 m*		654
MD2369	NS	0.55 A	15 ○	0.5	40	10 m	500	4.0	*15*	*20*	*.25*	*10*	*10 m*		654
MD2369A	NM	0.55 A	15 ○	0.5	40	10 m	500	4.0	**0.9**	**5.0**	*.25*	*10*	*10 m*		654
MD2905	PG	0.575 A	40 ○	0.6	100	150 m	200	8.0	*45*	*130*	*0.4*	*10*	*150 m*		654
MD2905A	PG	0.575 A	60 ○	0.6	100	150 m	200	8.0	*45*	*130*	*0.4*	*10*	*150 m*		654
MD2905AF	PG	0.35 A	60 ○	0.6	100	150 m	200	8.0	*45*	*130*	*0.4*	*10*	*150 m*		610A
MD3251	PA	0.575 A	40 ○	0.20	100	1.0 m	250	6.0			*.25*	*10*	*10 m*		654
MD3251A	PM	0.575 A	40 ○	0.20	100	1.0 m	250	6.0	**0.9**	**5.0**	*.25*	*10*	*10 m*		654
MD3251AF	PM	0.35 A	40 ○	0.20	100	1.0 m	250	6.0	**0.9**	**5.0**	*.25*	*10*	*10 m*		610A
MD3467	PS	0.60 A	40 ○	1.5	20	500 m	150	20	*40*	*110*	0.5	*10*	*500 m*		654
MD3467F	PS	0.35 A	40 ○	1.5	20	500 m	150	20	*40*	*110*	0.5	*10*	*500 m*		610A
MD3725	NS	0.60 A	40 ○	1.0	50	100 m	200	10	*45*	75	*.26*	*10*	*100 m*		654
MD3725F	NS	0.35 A	40 ○	1.0	50	100 m	200	10	*45*	75	*.26*	*10*	*100 m*		610A
MD3762	PS	0.60 A	40 ○	1.5	20	1.0 A	150	20	*40*	*110*	*1.0*	*10*	*1.0 A*		654
MD5000	PH	0.3 A	15 ○	0.05	20	3.0 m	600	1.7			**15**		**200 M**		654
MD5000A	PM	0.3 A	15 ○	0.05	20	3.0 m	600	1.7	**0.9**	**5.0**	**15**		**200 M**		654
MD6001	CG	.575 A	30 ○	0.5	40	150 m	200	8.0	*60*	*350*	*0.4*	*10*	*150 m*		654
MD6001F	CG	0.35 A	30 ○	0.5	40	150 m	200	8.0	60	*350*	*0.4*	*10*	*150 m*		610A
MD6002	CG	.575 A	30 ○	0.5	100	150 m	200	8.0	*60*	*350*	*0.4*	*10*	*150 m*		654
MD6002F	CG	0.35 A	30 ○	0.5	100	150 m	200	8.0	*60*	*350*	*0.4*	*10*	*150 m*		610A
MD6003	CA	.575 A	30 ○	0.5	70	150 m	200	8.0			*0.4*	*10*	*150 m*		654
MD6003F	CA	0.35 A	30 ○	0.5	70	150 m	200	8.0			*0.4*	*10*	*150 m*		610A
MD6100	CA	0.5 A	45 ○	0.05	100	0.1 m	30	4.0			*.25*	*10*	*1.0 m*		654
MD6100F	CA	0.35 A	45 ○	0.05	100	0.1 m	30	4.0			*.25*	*10*	*10 m*		610A
MD7000	NA	0.575 A	30 ○	0.5	70	150 m	200	8.0			*0.4*	*10*	*150 m*		654
MD7001	PA	0.6 A	30 ○	0.6	70	150 m	200	8.0			*0.4*	*10*	*150 m*		654
MD7001F	PA	0.350 A	30 ○	0.6	70	150 m	200	8.0			*0.4*	*10*	*150 m*		610A
MD7002	NA	0.575 A	40 ○	0.03	40	100 u	200	6.0			*.35*	*10*	*10 m*		654
MD7002A	NM	0.575 A	40 ○	0.03	40	100 u	200	6.0	**0.75**	**25**	*.35*	*10*	*10 m*		654
MD7003	NA	0.55 A	40 ○	0.05	50	10 m	200	6.0			*.35*	*10*	*1.0 m*		654
MD7003A	NM	0.55 A	40 ○	0.05	50	10 m	200	6.0	**0.75**	**25**	*.35*	*10*	*1.0 m*		654

Some columns show 2 different types of data indicated by either **bold** *or italic typefaces. See key and headings.*

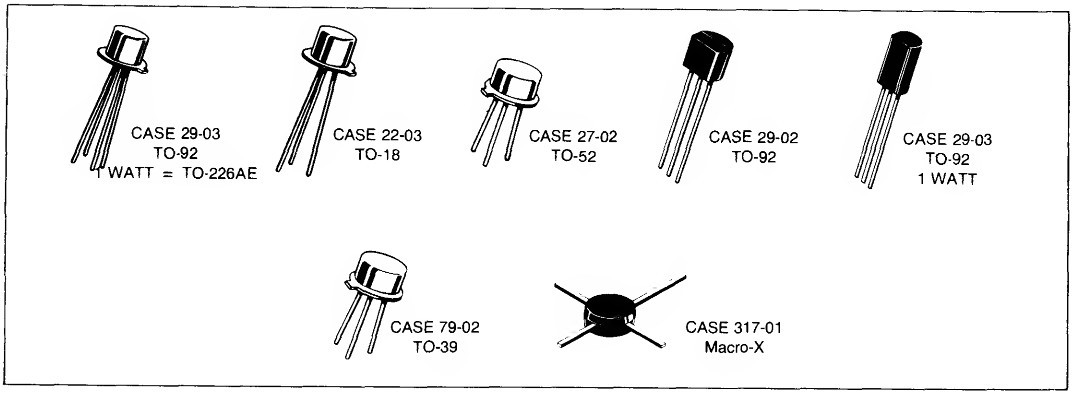
MULTIPLE SMALL-SIGNAL TRANSISTORS (continued)

TABLE 3. Dual Transistors (continued)

TYPE NO.	ID	P_D Watts One Die Only (Ref. Point)	V_{CE}· Volts (Subscript)	I_C Amp Max	h_{FE} Min	@ I_C (Unit)	f_T MHz Min	C_{ob} pF Max	**h_{FE1}/h_{FE2}** / *t_{on} ns Max*	**ΔV_{BE} mV Max** / *t_{off} ns Max*	**Gp dB Min** / *V_{CE} (sat) Volts Max @*	**NF dB Max** / *I_C/I_B*	@ f & I_C (Unit)	PACKAGE TO- No.	PACKAGE Case No.
MD7021	CG	0.55 A	40 ○	0.05	50	10 m	200	6.0	*28**	*72**	*.35*	*10*	*10 m*		654
MD7021F	CG	0.35 A	40 ○	0.05	50	10 m	200	6.0	*28**	*72**	*.35*	*10*	*10 m*		610A
MD8001	NM	0.575 A	40 ○	0.03	100	1.0 m	260*	2.6*		**15**					654
MD8002	NM	0.575 A	40 ○	0.03	100	1.0 m	260*	2.6*		**15**					654
MD8003	NM	0.575 A	40 ○	0.03	100	1.0 m	260*	2.6*		**15**					654
2N2060	NM	0.5 A	60 ○	0.5	30	100 u	60	15	**0.9**	**5.0**		**8.0**	**1000 H**	78	654
2N2223	NM	0.5 A	60 ○	0.5	25	100 u	50	15	**0.8**	**15**	*1.2*	*10*	*50 m*	78	654
2N2453	NM	0.5 A	30 ○	0.05	80	10 u	60	8.0	**0.9**	**3.0**		**7.0**	**1000 H**	78	654
2N2639	NM	0.3 A	45 ○	0.03	50	10 u	80	8.0	**0.9**	**5.0**		**4.0**	**AUD**	78	654
2N2641	NE	0.3 A	45 ○	0.03	50	10 u	80	8.0				**4.0**	**AUD**	78	654
2N2642	NM	0.3 A	45 ○	0.03	100	10 u	80	8.0	**0.9**	**5.0**		**4.0**	**AUD**	78	654
2N2644	NE	0.3 A	45 ○	0.03	100	10 u	80	8.0				**4.0**	**AUD**	78	654
2N2652	NM	0.3 A	60 ○	0.5	50	1.0 m	60	15	**0.85**	**3.0**	*1.2*	*10*	*50 m*	78	654
2N2722	NM	0.3 A	45 ○	0.04	50	1.0 u	100	6.0	**0.9**	**5.0**	*1.0*	*20*	*10 m*	78	654
2N2903	NM	0.6 C	30 ○	0.05	125	1.0 m	60	8.0	**0.8**	**10**		**7.0**	**1000 H**	78	654
2N2903A	NM	0.6 C	30 ○	0.05	125	1.0 m	60	8.0	**0.9**	**5.0**		**7.0**	**1000 H**	78	654
2N2913	NE	0.3 A	45 ○	0.03	60	10 u	60	6.0				**4.0**	**AUD**		654
2N2914	NE	0.3 A	45 ○	0.03	150	10 u	60	6.0				**3.0**	**AUD**		654
2N2915	NM	0.3 A	45 ○	0.03	60	10 u	60	6.0	**0.9**	**5.0**		**4.0**	**AUD**		654
2N2916	NM	0.3 A	45 ○	0.03	150	10 u	60	6.0	**0.9**	**5.0**		**3.0**	**AUD**		654
2N2917	NM	0.3 A	45 ○	0.03	60	10 u	60	6.0	**0.8**	**10**		**4.0**	**AUD**		654
2N2918	NM	0.3 A	45 ○	0.03	150	10 u	60	6.0	**0.8**	**10**		**3.0**	**AUD**		654
2N2919	NM	0.3 A	60 ○	0.03	60	10 u	60	6.0	**0.9**	**5.0**		**4.0**	**AUD**		654
2N2920	NM	0.3 A	60 ○	0.03	150	10 u	60	6.0	**0.9**	**5.0**		**3.0**	**AUD**		654
2N3043	NM	0.25 A	45 ○	0.03	100	10 u	30	8.0	**0.9**	**5.0**		**5.0**	**AUD**		610A
2N3045	NE	0.25 A	45 ○	0.03	100	10 u	30	8.0				**5.0**	**AUD**		610A
2N3046	NM	0.25 A	45 ○	0.03	50	10 u	30	8.0	**0.9**	**5.0**		**5.0**	**AUD**		610A
2N3048	NE	0.25 A	45 ○	0.03	50	10 u	30	8.0				**5.0**	**AUD**		610A
2N3726	PE	0.4 A	45 ○	0.3	135	1.0 m	200	8.0	**0.9**	**5.0**		**4.0**	**1000 H**		654
2N3806	PE	0.5 A	60 ○	0.05	150	0.1 m	100	4.0				**7.0**	**100 H**		654
2N3807	PE	0.5 A	60 ○	0.05	300	0.1 m	100	4.0				**4.0**	**100 H**		654
2N3808	PM	0.5 A	60 ○	0.05	150	0.1 m	100	4.0	**0.8**	**5.0**		**7.0**	**100 H**		654
2N3809	PM	0.5 A	60 ○	0.05	300	0.1 m	100	4.0	**0.8**	**5.0**		**4.0**	**100 H**		654
2N3810	PM	0.5 A	60 ○	0.05	150	0.1 m	100	4.0	**0.9**	**3.0**		**7.0**	**100 H**		654
2N3810A	PM	0.5 A	60 ○	0.05	150	0.1 m	100	4.0	**0.95**	**1.5**		**3.0**	**100 H**		654
2N3811	PM	0.5 A	60 ○	0.05	300	0.1 m	100	4.0	**0.9**	**3.0**		**4.0**	**100 H**		654
2N3811A	PM	0.5 A	60 ○	0.05	300	0.1 m	100	4.0	**0.95**	**1.5**		**1.5**	**100 H**		654
2N3813	PA	0.5 A	60 ○	0.05	300	0.1 m	100	4.0				**2.5**	**AUD**		610A
2N3816	PM	0.5 A	60 ○	0.05	150	0.1 m	100	4.0	**0.9**	**3.0**		**7.0**	**100 H**		610A
2N3817	PM	0.5 A	60 ○	0.05	300	0.1 m	100	4.0	**0.9**	**3.0**		**4.0**	**100 H**		610A
2N3838	CE	0.25 A	40 ○	0.6	100	150 m	200	8.0	*50*	*340*		**8.0**	**1000 H**		610A
2N4015	PM	0.4 A	60 ○	0.3	135	1.0 m	200	8.0	**0.9**	**5.0**		**4.0**	**1000 H**		654
2N4016	PM	0.4 A	60 ○	0.3	135	1.0 m	200	8.0	**0.9**	**2.5**		**4.0**	**1000 H**		654
2N4854	CE	0.3 A	40 ○	0.6	100	150 m	200	8.0	*60*	*350*		**8.0**	**1000 H**		654
2N4937	PM	0.6 A	40 ○	0.05	50	1.0 m	300	5.0	**0.9**	**3.0**		**4.0**	**AUD**		654
2N4939	PE	0.6 A	40 ○	0.05	50	1.0 m	300	5.0				**4.0**	**AUD**		654
2N4941	PM	0.6 A	40 ○	0.05	50	1.0 m	300	5.0	**0.9**	**3.0**		**4.0**	**AUD**		610A
2N4942	PE	0.6 A	40 ○	0.05	50	1.0 m	300	5.0				**4.0**	**AUD**		610A
2N5794	NG	0.5 A	40 ○	0.6	100	150 m	200	8.0	*45*	*310*	*0.3*	*10*	*150 m*		654
2N5796	NG	0.5 A	60 ○	0.6	100	150 m	200	8.0	*47*	*140*	*0.4*	*10*	*150 m*		654

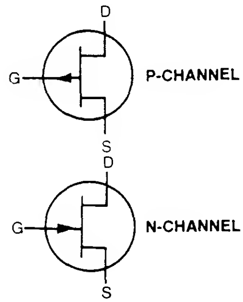
Some columns show 2 different types of data indicated by either **bold** *or italic typefaces. See key and headings.*

Field-Effect Transistors



Motorola offers a line of field-effect transistors that encompasses the latest technology and covers the full range of FET applications. Included here is a wide variety of junction FETs, MOSFETs (with P- or N-channel polarity with both single and dual gates) and TMOS FETs. These FETs include devices developed for operation across the frequency range from dc to UHF in switching and amplifying applications. Package options from low cost plastic to metal TO-72 packages are available. The selector guides on the following pages are designed to emphasize those FET families and device types that, by virtue of widespread industry use, ease of manufacture and, consequently, low relative cost, merit first consideration for new equipment design.

JFETs



JFETs

TABLE 1. Switches and Choppers

JFETs operate in the depletion mode. They are available in both P- and N-channel and are offered in both metal and plastic packages. Applications include general-purpose amplifiers, switches and choppers, and RF amplifiers and mixers. These devices are economical and very rugged. The drain and source are interchangeable on many typical FETs.

P-Channel JFETs

		$r_{ds(on)}$		$V_{GS(off)}$		I_{DSS}		$V_{(BR)GSS}$ $V_{(BR)GDO}$	C_{iss}	C_{rss}	t_{on}	t_{off}
Package TO–	Device	(Ω) MAX	@ I_D (μA)	(V) MIN	(V) MAX	(mA) MIN	(mA) MAX	(V) MIN	(pF) MAX	(pF) MAX	(ns) MAX	(ns) MAX
92	MPF970	100	1.0	5.0	12	15	100	30	12	5.0	8.0	25
92	MPF971	250	1.0	1.0	7.0	2.0	80	30	12	5.0	10	120
72	2N3993	150	—	4.0	9.5	10	—	25	16	4.5	—	—
72	2N3994	300	—	1.0	5.5	2.0	—	25	16	4.5	—	—

N-Channel JFETs

18	2N4859A	25	—	2.0	6.0	50	—	30	10	4.0	8.0	20
18	2N4856A	25	—	4.0	10	50	—	40	10	4.0	8.0	20
18	2N4856	26	—	4.0	10	50	—	40	10	8.0	9.0	25
18	2N4859	25	—	4.0	10	50	—	30	18	8.0	9.0	25
18	2N4391	30	1.0	4.0	10	50	150	40	14	3.5	15	20
92	MPF4391	30	1.0	4.0	10	60	130	20	10	3.5	15	20
18	2N4091	30	1.0	5.0	10	30	—	40	16	5.0	25	40
92	MPF4091	30	1.0	5.0	10	30	—	40	16	5.0	25	40
92	J111	30	1.0	3.0	10	20	—	35	10^t	5.0^t	13	35
18	2N4857A	40	—	2.0	6.0	20	100	40	10	3.5	10	40

FIELD-EFFECT TRANSISTORS (continued)

TABLE 1. Switches and Choppers (continued)

N-Channel JFETs

Package TO —	Device	$r_{ds(on)}$ (Ω) MAX	@ I_D (μA)	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	C_{iss} (pF) MAX	C_{rss} (pF) MAX	t_{on} (ns) MAX	t_{off} (ns) MAX
18	2N860A	40	—	2.0	6.0	20	100	30	10	3.5	10	40
18	2N4857	40	—	2.0	6.0	20	100	40	18	8.0	10	50
18	2N4860	40	—	2.0	6.0	20	100	30	18	8.0	10	50
18	2N4092	50	1.0	2.0	7.0	15	—	40	16	5.0	35	60
92	MPF4092	50	1.0	2.0	7.0	15	—	40	16	5.0	35	60
92	J112	50	1.0	1.0	5.0	5.0	—	35	10^t	5.0^t	13^t	35^t
18	2N4392	60	1.0	2.0	5.0	25	75	40	14	3.5	15	35
92	MPF4392	60	1.0	2.0	5.0	25	75	20	10	3.5	15	35
18	2N4858A	60	1.0	0.8	4.0	8.0	80	40	10	3.5	16	80
18	2N4861A	60	—	0.8	4.0	8.0	80	30	10	3.5	16	80
92	2N5639	60	1.0	—	$(8.0)^t$	25	—	30	10	4.0	14	30
18	2N3971	60	1.0	2.0	5.0	25	75	40	25	6.0	30	60
18	2N4858	60	—	0.8	4.0	8.0	80	40	18	8.0	20	100
18	2N4861	60	—	0.8	4.0	8.0	80	30	18	8.0	20	100
18	2N4093	80	1.0	1.0	5.0	80	—	40	16	5.0	60	80
92	MPF4093	80	1.0	1.0	5.0	80	—	40	16	5.0	60	80
72	MPF3002	100	10 V	—	3.0	—	10	15	5.0	1.5	—	—
18	2N4393	100	1.0	0.5	3.0	5.0	30	40	14	3.5	15	50
92	MPF4393	100	1.0	0.5	3.0	5.0	30	20	10	3.5	15	55
92	2N5640	100	1.0	—	(6.0)	5.0	—	30	10	4.0	18	45
18	2N3972	100	1.0	0.5	3.0	5.0	30	40	25	6.0	80	100
92	J113	100	1.0	0.5	3.0	2.0	—	35	10^t	5.0^t	13^t	35^t
92	BF246A/247A	35^t	1.0	1.5	4.0	30	80	25	—	—	—	—
92	BF246B/247B	50^t	1.0	3.0	7.0	60	140	25	—	—	—	—
92	BF246C/247C	65^t	1.0	5.5	12.0	110	250	25	—	—	—	—
92	J107	8	—	0.5	4.5	100	—	25	—	—	—	—
92	J108	8	—	3.0	10.0	80	—	25	—	—	—	—
92	J109	12	—	2.0	6.0	40	—	25	—	—	—	—
92	J110	18	—	0.5	4.0	10	—	25	—	—	—	—

t = typical

TABLE 2. Low-Frequency/Low-Noise

P-Channel JFETs

Package TO —	Device	$R_e\ Y_{fs}$ (mmho) MIN	$R_e\ Y_{os}$ (μmho) MAX	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
72	2N3909	1.0	100	32	16	20	0.3	7.9	0.3	15
18	2N2608	1.0	17	—	—	30	1.0	4.0	0.9	4.5
92	2N5460	1.0	50	7.0	2.0	40	0.75	6.0	1.0	5.0
92	2N5463	1.0	75	7.0	2.0	60	0.5	4.0	1.0	5.0
92	2N5461	1.5	50	7.0	2.0	40	1.0	7.5	2.0	9.0
92	2N5464	1.5	75	7.0	2.0	60	0.8	4.5	2.0	9.0

FIELD-EFFECT TRANSISTORS (continued)

TABLE 2. Low-Frequency/Low-Noise (continued)

P-Channel JFETs

Package TO—	Device	$R_e\ Y_{fs}$ (mmho) MIN	$R_e\ Y_{os}$ (μmho) MAX	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
92	2N4360	2.0	100	20	5.0	20	0.4	9.0	3.0	30
92	2N5462	2.0	50	7.0	2.0	40	1.8	9.0	4.0	16
92	2N5465	2.0	75	7.0	2.0	60	1.5	6.0	4.0	16
18	2N2609	2.5	—	30	—	30	1.0	4.0	2.0	10
72	2N5270	2.5	75	7.0	2.0	60	2.0	6.0	7.0	14

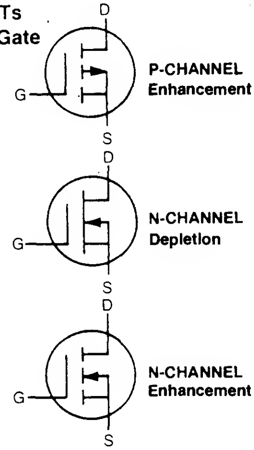
N-Channel JFETs

Package TO—	Device	$R_e\ Y_{fs}$ (mmho) MIN	$R_e\ Y_{fs}$ @ VDS (V)	$R_e\ Y_{os}$ (μmho) MAX	$R_e\ Y_{os}$ @ VDS (V)	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
92	MPF111	0.5	10	200	10	—	—	20	0.5	10	0.5	20
92	J201	0.5	20	1.0[t]	20	5.0[t]	2.0[t]	40	0.3	1.5	0.2	1.0
92	MPF109	0.8	15	75	15	7.0	3.0	25	0.2	8.0	0.5	24
72	2N4220	1.0	15	10	15	6.0	2.0	30	—	4.0	0.5	3.0
72	2N5360	1.4	15	20	15	6.0	2.0	40	0.8	4.0	0.5	2.5
94	2N5458	1.5	15	50	15	7.0	3.0	25	1.0	7.0	2.0	9.0
72	2N5361	1.5	15	20	15	6.0	2.0	40	1.0	6.0	2.5	5.0
92	J203	1.5	20	10[t]	20	5.0[t]	2.0[t]	40	2.0	10	4.0	20
72	2N3821	1.5	15	10	15	6.0	3.0	50	—	4.0	0.5	2.5
92	MPF3821	1.5	15	10	15	6.0	3.0	50	—	4.0	0.5	2.5
92	2N5457	2.0	15	50	15	7.0	3.0	25	0.5	6.0	1.0	5.0
92	2N5459	2.0	15	50	15	7.0	3.0	25	2.0	8.0	4.0	16
72	2N4221	2.0	15	20	15	6.0	2.0	30	—	6.0	2.0	6.0
92	BC264A	2.5	15	40[t]	15	3[t]	0.7[t]	30	0.5	8.0	2.0	4.5
92	BC264B	3.0	15	40[t]	15	3[t]	0.7[t]	30	0.5	8.0	3.5	6.5
92	BC264C	3.5	15	40[t]	15	3[t]	0.7[t]	30	0.5	8.0	5.0	8.0
92	BC264D	4.0	15	40[t]	15	3[t]	0.7[t]	30	0.5	8.0	7.0	12.0
92	BF244A/45A	3.0	15	40[t]	15	3[t]	0.7[t]	30	0.4	2.2	2.0	6.5
92	BF244B/45B	3.0	15	40[t]	15	3[t]	0.7[t]	30	1.6	3.8	6.0	15.0
92	BF244C/45C	3.0	15	40[t]	15	3[t]	0.7[t]	30	3.2	7.5	12.0	25.0
92	BF256A	4.5	15	—	—	—	0.7[t]	30	0.5	7.5	3.0	7.0
92	BF256B	4.5	15	—	—	—	0.7[t]	30	0.5	7.5	6.0	13.0
92	BF256C	4.5	15	—	—	—	0.7[t]	30	0.5	7.5	11.0	18.0
72	2N4221A	2.0	15	20	15	6.0	2.0	30	—	6.0	2.0	6.0
72	2N5362	2.0	15	40	15	6.0	2.0	40	2.0	7.0	4.0	8.0
72	2N3822	2.0	15	20	15	6.0	3.0	50	—	6.0	2.0	10
18	2N4341	2.0	15	60	15	7.0	3.0	50	2.0	6.0	3.0	9.0
72	2N4222	2.5	15	40	15	6.0	2.0	30	—	8.0	5.0	15
72	2N4222A	2.5	15	40	15	6.0	2.0	30	—	8.0	5.0	15
72	2N5363	2.5	15	40	15	6.0	2.0	40	2.5	8.0	7.0	14
72	2N4117	20	0.001	3.0	10	3.0	1.5	40	0.6	1.8	30	90
72	2N4117A	70	0.001	3.0	10	3.0	1.5	40	0.6	1.8	30	90
72	2N4118	80	0.001	5.0	10	3.0	1.5	40	1.0	3.0	80	240
72	2N4118A	80	0.001	5.0	10	3.0	1.5	40	1.0	3.0	80	240

t = typical.

FIELD-EFFECT TRANSISTORS (continued)

MOSFETs
Single Gate



MOSFETs

MOSFETs are available in either depletion/enhancement or enhancement mode (in general, depletion/enhancement devices are operated in the depletion mode and are referred to as depletion devices). They are available in both N- and P-channel, and both single gate and dual gate construction. Some MOSFETs are also offered with input diode protection which reduces the chance of damage from static charge in handling.

TABLE 2. Low-Frequency/Low-Noise (continued)

P-Channel MOSFETs

Package TO—	Device	$R_e\|Y_{fs}\|$ (mmho) MIN	(μmho) MAX	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	$V_{(BR)DDS}$ (V) MIN	$V_{GS(TH)}$ (V) MIN	MAX	I_{DSS} (mA) MIN	MAX
72	3N155A	1.0	60	5.0	1.3	—35	—1.5	—3.2	—	—0.25
18	MFE823	1.0	—	6.0	1.5	—50	—3.0	—5.0	—	—0.25
72	MFE3003	—	—	5.0	1.0	—15	—	—4.0	—	10

N-Channel MOSFETs

Package TO—	Device	$R_e\|Y_{fs}\|$ (mmho) MIN	(μmho) MAX	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	$V_{(BR)DDS}$ (V) MIN	$V_{GS(TH)}$ (V) MIN	MAX	I_{DSS} (mA) MIN	MAX
18	2N3796	0.4	1.8	7.0	0.8	25	—	—7.0	2.0	6.0
18	MFE825	0.5	—	4.0	0.7	20	—	—	1.0	25
72	2N4351	1.0	—	5.0	1.3	25	1.0	5.0	—	10
72	3N169	1.0	—	5.0	1.3	25	0.5	1.5	—	10
72	3N170	1.0	—	5.0	1.3	25	1.0	2.0	—	10
72	3N171	1.0	—	5.0	1.3	25	1.5	3.0	—	10
72	MFE3002	—	—	5.0	1.0	15	—	3.0	—	10
18	2N3797	1.5	—	8.0	0.8	25	—	—7.0	2.0	6.0

TABLE 3.

N-Channel JFETs

Package TO-	Device	$R_e\|Y_{fs}\|$ (mmho) MIN	@ f (MHz)	$R_e\|Y_{os}\|$ (μmho) MAX	@ f (MHz)	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	NF (dB) MAX	@ RG = 1K f (MHz)	$V_{(BR)DSS}$ $V_{(BR)GDO}$ (V) MIN	$V_{GS(off)}$ (V) MIN	MAX	I_{DSS} (mA) MIN	MAX
92	2N5484	2.5	100	75	100	5.0	1.0	3.0	100	25	0.3	3.0	1.0	5.0
92	2N5485	3.0	400	100	400	5.0	1.0	4.0	400	25	1.0	4.0	4.0	10
92	J305	3.0^{t}	400	80^{t}	100	3.0^{t}	0.8^{t}	4.0^{t}	400	30	0.5	3.0	1.0	8.0
72	2N3823	3.2	200	200	200	6.0	2.0	2.5	100	30	—	8.0	4.0	20
92	2N5486	3.5	400	100	400	5.0	1.0	4.0	400	25	2.0	6.0	8.0	20
72	2N4416	4.0	400	100	400	4.0	0.8	4.0	400	30	2.0	6.0	5.0	15
72	2N4416A	4.0	400	100	400	4.0	0.8	4.0	400	30	2.0	6.0	5.0	15
92	2N5245	4.0	400	100	400	4.5	1.0	4.0	400	30	1.0	6.0	5.0	15
92	J304	4.2^{t}	400	80^{t}	100	3.0^{t}	0.8^{t}	4.0^{t}	400	30	2.0	6.0	5.0	15
52	U310	10	0.001	150	100	5.0	2.5	3^{t}	450	25	2.5	6.0	24	60
92	J308	12^{t}	100	250^{t}	100	7.5	2.5	1.5^{t}	100	25	1.0	6.5	12	60
92	J309	12^{t}	100	250^{t}	100	7.5	2.5	1.5^{t}	100	25	1.0	4.0	12	30
92	J310	12^{t}	100	250^{t}	100	7.5	2.5	1.5^{t}	100	25	2.0	6.5	24	60
72	3N128*	5.0	0.001	500	200	7.0	0.28	5.0	200	—50	—0.5	—8.0	5.0	25

t = typical

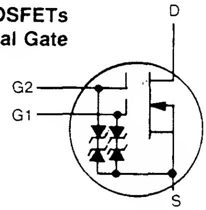
*N-Channel MOSFET

FIELD-EFFECT TRANSISTORS (continued)

MOSFETs
Dual Gate MOSFETs

These devices are especially suited for RF amplifier and mixer applications in TV tuners, radio, etc. The Dual Gate construction also allows easy AGC control with very low power.

MOSFETs
Dual Gate



N-CHANNEL

Dual Gate MOSFETs

Package TO —	Device	$R_e\|Y_{fs}\|$ (mmho) MIN	@ f (MHz)	$R_e\|Y_{os}\|$ (µmho) MAX	@ f (MHz)	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	NF (dB) MAX	NF @ RG = 1K f (MHz)	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
72	3N211	17	0.001			—	0.05	3.5	200	±6.0	—0.2	—5.5	6.0	40
72	3N213	15	0.001			—	0.05	4.0	45	±6.0	—0.2	—5.5	6.0	40
72	3N212	17	0.001			—	0.05	4.0	45	±6.0	—0.2	—4.0	6.0	40
72	3N203	7.0	0.001			4.3t	0.03	4.5	200	±6.0	—0.2	—5.0	3.0	11
72	3N201	8.0	0.001			4.5t	0.03	4.5	200	±6.0	—0.2	—5.0	6.0	30
72	3N202	8.0	0.001			4.3t	0.03	4.5	200	±6.0	—0.2	—5.0	6.0	30
72	3N204	10	0.001			—	0.03	5.0	400	25	—0.2	—4.0	6.0	30
72	3N205	10	0.001			—	0.03	5.0	400	25	—0.2	—4.0	6.0	30

t = typical

FIELD-EFFECT TRANSISTORS (continued)

Small-Signal TMOS

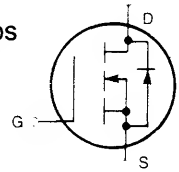
TABLE 4. TMOS Power MOSFETs

Power MOSFETs, Motorola trademark TMOS, are FET transistors with an oxide insulated gate which controls vertical current flow.

This basic description fits a number of structures and process titles including Vertical DMOS, HEXMOS, TMOS, UMOS, Vertical MOS, and VMOS.

There are subtle parametric tradeoffs with these different products but they all exhibit higher input impedance, faster switching, enhanced thermal stability, and easier paralleling than bipolar transistors. In addition, they have lower "on" resistance and higher power handling capability than conventional horizontal MOSFETs or JFETs.

TMOS



N-CHANNEL

N-Channel

Package TO –	Device	$r_{ds(on)}$ (Ω) MAX	@ I_D (A)	$V_{GS(th)}$ (V) MIN	$V_{GS(th)}$ (V) MAX	I_{DSS} (µA) MAX	$V_{(BR)DSS}$ (V) MIN	I_{GSS} (nA) MAX	C_{iss} (pF) MAX	C_{rss} (pF) MAX	t_{on} (ns) MAX	t_{off} (ns) MAX
39	MFE930	1.4	1.0	1.0	3.5	10	35	50	70	18	15	15
226AE	MPF930	1.4	1.0	1.0	3.5	10	35	50	70	18	15	15
39	MFE960	1.7	1.0	1.0	3.5	10	60	50	70	18	15	15
226AE	MPF960	1.7	1.0	1.0	3.5	10	60	50	70	18	15	15
39	MFE990	2.0	1.0	1.0	3.5	10	90	50	70	18	15	15
226AE	MPF990	2.0	1.0	1.0	3.5	10	90	50	70	18	15	15
18	MFE9200	6.4	.250	1.0	4.0	10	200	50	90	3.5	15	15
92	MPF9200	6.4	.250	1.0	4.0	10	200	50	90	3.5	15	15
92	BS107	14	0.20	1.0	2.6	0.03	200	10	90	3.5	15	15
92	BS170	5.0	0.20	0.8	3.0	0.5	60	10	38^t	4.5^t	10	10
226AE	MPF910	5.0	0.50	0.8	2.5	10	60	10	38^t	4.5^t	5.0^t	5.0^t
226AE	MPF6659	1.8	1.0	0.8	2.0	500	35	100	50	10	5.0	5.0
226AE	MPF6660	3.0	1.0	0.8	2.0	500	60	100	50	10	5.0	5.0
226AE	MPF6661	4.0	1.0	0.8	2.0	500	90	100	50	10	5.0	5.0
39	2N6659	1.8	1.0	0.8	2.0	10	35	100	50	10	5.0	5.0
39	2N6660	3.0	1.0	0.8	2.0	10	60	100	50	10	5.0	5.0
39	2N6661	4.0	1.0	0.8	2.0	10	90	100	50	10	5.0	5.0
226AE	MPF1010	—	—	0.3	2.5	10	100	10	35^t	6^t	5.0^t	5.0^t
39	MFE910	5.0	0.5	0.3	2.5	10	60	10	—	—	5.0^t	5.0^t

t = typical

GaAs FETs

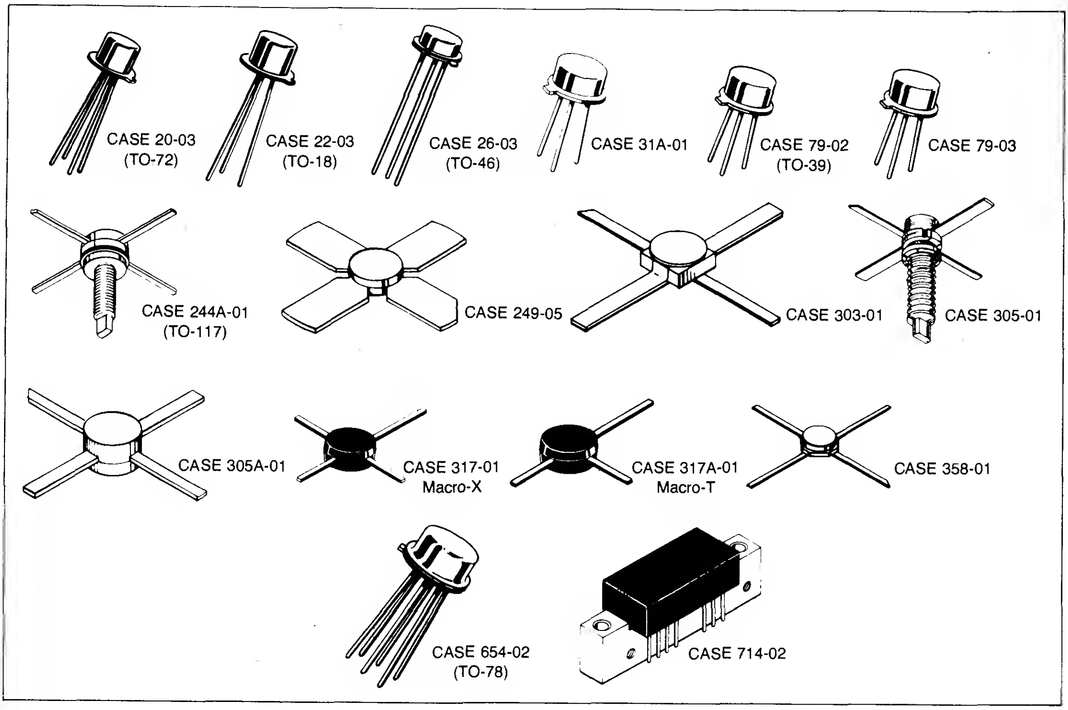
TABLE 5. GaAs Dual Gate Field-Effect Transistors

The GaAs Dual Gate FETs listed here are for low noise and high gain receiver amplifier and mixer applications.

Device Type	I_{DSS} Typ: I_{DSS} (mA)	I_{DSS} Typ: Vds	Noise Figure: NF dB	Noise Figure: f MHz	Noise Figure: I_D mA	Gain: dB Min	Gain: f MHz	Ind_3 dB	MdB dBm	$V_{(BR)DSX}$	I_D mA	P_T mW	Package
MRF966	50	5.0	1.2*	1000	10	15	1000	−65*	10*	10	60	350	317-1
MRF967	50	5.0	1.2*	1000	10	13	1000	−65*	10*	10	60	350	358-1

*Typ

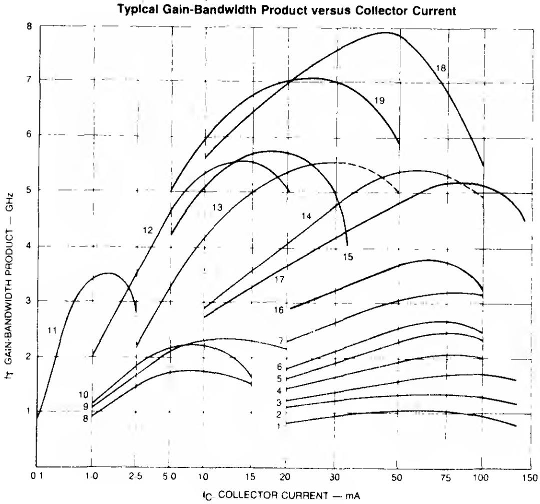
RF Small-Signal Transistors



Motorola's small-signal, low power RF transistor product range includes transistors with gain-bandwidths of 1.0 GHz to 8.0 GHz operating at currents of 0.25 mA to over 140 mA.

These devices are available in a wide variety of package types; metal can, plastic Macro-X and Macro-T, hermetic ceramic and microminiature. Most of these transistors are fully characterized with y or s parameters; and in addition, there are non-saturated switching characteristics, low power driver specifications, and noise figure limits. QPL types with JAN, JTX and JTXV processing levels are available as well as Hi Rel processing to meet unique customer requirements.

Typical Gain-Bandwidth Product versus Collector Current



RF Small-Signal Transistors

Motorola small-signal and medium power RF transistors with gain-bandwidth products from 1.0 GHz to 8.0 GHz operate with currents from 0.25 mA to over 140 mA. The following chart, combined with the tables of package options, enables the circuit designer to select the optimum device from Motorola's wide range of transistor/package combinations.

1 2N3866, 2N3866A, MM8000
2 2N5160, MM4018, PNP
3 2N3948, 2N4427, MRF207
4 2N5109, 2N5943, MM8001, MM8002
5 2N5583, PNP
6 2N5836, 2N5837
7 MRF511, MRF517, MRF525
8 2N2857, 2N3839, 2N5179, MRF501, MRF502
9 2N6304, 2N6305, BFX89, BFY90
10 2N4957, 2N4958, 2N4959, PNP
11 MRF931
12 2N6603, BFR90, MRF901, MRF904
13 2N6604, BFR91, MRF911, MRF914
14 BFR96, MRF961, MRF962, MRF965
15 BFW92A
16 MRF559
17 MRF580, MRF581, MRF586, MRF587
18 MRF571, MRF572, MRF573
19 MRF536, MRF534, MM4049, PNP

RF SMALL-SIGNAL TRANSISTORS (continued)

TABLE 1. UHF and Microwave Oscillators

The transistors listed below are for UHF and microwave oscillator applications as initial signal sources or as output stages of limited range transmitters. Devices are listed in order of increasing output power.

Device Type	Test Conditions f MHz	Test Conditions V_{CC} Volts	P_{out} mW Min	f_T MHz Typ	Package
2N5179	500	10	20	1800	TO-72
2N2857	500	10	30	1800	TO-72
2N3839	500	6.0	30	1800	TO-72
MM8009	1680	20	200	1400	TO-39
2N5108	1680	20	300	1400	TO-39
MRF905	1680	20	500*	2200	TO-46
2N3866	400	15	1000	1000	TO-39

*Typical

TABLE 2. GaAs Dual Gate Field-Effect Transistors

The GaAs Dual Gate N-Channel FET's listed here are for low noise and high gain receiver amplifier and mixer applications.

	I_{DSS} Typ		Noise Figure			Gain		IMD_3	P_1dB				
Device Type	I_{DSS} (mA)	Vds	NF dB	f MHz	I_D mA	dB Min	f MHz	dB	dBm	$V_{(BR)DSX}$	I_D mA	P_T mW	Package
MRF966	50	5.0	1.2*	1000	10	15	1000	−65*	10*	10	60	350	317-1
MRF967	50	5.0	1.2*	1000	10	13	1000	−65*	10*	10	60	350	358-1

*Typical

TABLE 3. Low-Noise Transistors

The low-noise devices listed are produced with carefully controlled r_b' and f_T to optimize device noise performance. Devices listed in the matrix are classified according to noise figure performance versus frequency.

NF dB	Frequency MHz 60	100	200	450	1000	2000	Polarity
1.5	2N5829 2N5031	2N5829 2N5031	MRF904	MRF571	MRF572		PNP NPN
2.0	2N4957 2N5032	2N4957 2N5032	2N5829 2N5031	MRF904	MRF901		PNP NPN
2.5	2N4958 2N5032	2N4958 2N5032	2N4957 2N5032	2N5829 2N5031	MRF901 2N6603	MRF572 MRF573	PNP NPN NPN
3.0	2N4959 2N2857	2N4959 2N2857	2N4958 2N5032	2N4957 2N5032	2N5829 MRF901 2N6604	2N6603	PNP NPN NPN
3.5	2N4959 2N5179	2N4959 2N5179	2N4959 2N2857	2N4958 2N5032	2N4957 2N5031	MRF901	PNP NPN
4.0	2N4959 2N5179	2N4959 2N5179	2N4959 2N5179	2N4959 2N2857	2N4958 2N5031	2N6604	PNP NPN
4.5	2N4959 2N5179	2N4959 2N5179	2N4959 2N5179	2N4959 2N2857	2N4959 2N5032		PNP NPN

RF SMALL-SIGNAL TRANSISTORS (continued)

TABLE 4. CATV, MATV, and Class A Linear Transistors

The devices listed below are excellent for Class A linear CATV/MATV applications and are listed according to increasing gain-bandwidth (f_T). More information concerning the device for your specific linear design needs can be obtained through your local Motorola Sales Office or Motorola distributor.

Device Type	Nominal Test Conditions V_{CE}/I_C Volts/mA	f_T MHz Min	Noise Figure Max/Freq. dB/MHz	Distortion Specifications 2nd Order IMD	3rd Order IMD	12 Ch. Cross-Mod.	Output Level dBmV	Package
MRF501	6/5	600	4.5*/200					TO-72
MRF502	6/5	800	4.0*/200					TO-72
2N5179	6/5	900	4.5/200					TO-72
BFY90	5/2	1000	5.0/500					TO-72
2N6305	5/10	1200	5.5/450					TO-72
BFX89	5/25	1200	6.5/500					TO-72
2N5109	15/50	1200	3.0*/200					TO-39
2N5943	15/50	1200	3.4/200	−50		−42	+50	TO-39
2N6304	5/10	1400	4.5/450					TO-72
MRF511	20/80	1500	7.3*/200	−50	−65	−57	+50	244A-01
2N5947	20/75	1500*	3.8/200		−55	−60	+50	244A-01
MRF517	15/60	2200	7.5/300	−60	−72	−57	+45	TO-39
BFW92A	5/2	4500*	3.0*/500					317A-01
MRF586	14/70	4500*	3.0/500	−50	−72		+50	TO-39
BFR90	10/14	5000*	2.4*/500					317A-01
BFR91	5/35	5000*	1.9*/500					317A-01
BFR96	10/50	5000*	3.0*/500					317A-01
MRF961	10/50	5000*	2.0*/500					317-01
MRF962	10/50	5000*	2.0*/500					303-01
MRF965	10/50	5000*	2.0*/500					TO-46
MRF581	10/75	5000*	3.0/500		−65		+50	317-01
MRF587	14/70	5500*	3.0/500	−52	−72		+50	244A-01

*Typ

TABLE 5. High-Speed Switches

The transistors listed below are for use as high-frequency current-mode switches. They are also suitable for RF amplifier and oscillator applications. The devices are listed in ascending order of collector current.

Device Type	Test Conditions I_C/V_{CE} mA/Volts	f_T MHz Min	$r_b'C_C$ Max	Package
2N3959	10/10	1300	25	TO-18
2N3960	10/10	1600	40	TO-18
2N5835	10/6.0	2500	5.0**	TO-72
MM4049*	20/5.0	4000	15	TO-72
MRF914	20/10	4500**	—	TO-72
2N5842	25/4.0	1700	40	TO-72
2N5841	25/4.0	2200	25	TO-72
2N5943	50/15	1200	5.5**	TO-39
2N5583*	50/10	1000	8.0**	TO-39
2N5836	50/6.0	2000	6.0**	TO-46
2N5837	100/3.0	1700	6.0**	TO-46

*PNP **Typ

RF SMALL-SIGNAL TRANSISTORS (continued)

Class C Amplifiers

The transistors listed in these tables are specified for operation in Class C RF power amplifier circuits. The tables are arranged by increasing frequency of operation first, then by increasing output power. The first table contains those devices specified at 12.5 Vdc, while the following table contains devices specified at 28 Vdc.

TABLE 6. Low-Voltage Class C Amplifiers

Device Type	Frequency (MHz)	P_{in} (w)	P_{out} (w)	G_{pe} dB	Voltage (V)	Case Outline
MRF8003	27	0.05	0.5	10.0	12.5	TO-39
MRF8004	27	0.35	3.5	10.0	12.5	TO-39
MRF402	50	0.1	1.0	10.0	12.5	TO-39
MRF229	90	0.15	1.5	10.0	12.5	TO-39
MRF230	90	0.15	1.5	10.0	12.5	TO-39
MRF604	175	0.1	1.0	10.0	12.5	TO-46
2N4427	175	0.1	1.0	10.0	12.0	TO-39
MRF607	175	0.12	1.75	11.5	12.5	TO-39
2N6255	175	0.5	3.0	7.8	12.5	TO-39
MRF237*	175	0.25	4.0	12.0	12.5	TO-39
MRF207	220	0.15	1.0	8.2	12.5	TO-39
MRF225	225	0.18	1.5	9.0	12.5	TO-39
MRF227*	225	0.13	3.0	13.5	12.5	TO-39
2N3948	400	0.25	1.0	6.0	13.6	TO-39
2N6256	470	0.1	0.5	7.0	12.5	249-5
MRF515	470	0.12	0.75	8.0	12.5	TO-39
MRF581	470	0.05	1.2	13.8	12.5	317-1
MRF629*	470	0.32	2.0	8.0	12.5	TO-39
MRF626	470	0.05	0.5	10.0	12.5	305-1
MRF627	470	0.05	0.5	10.0	12.5	305A-1
MRF628	470	0.05	0.5	10.0	12.5	249-5
MRF630	470	0.25	3.0	10.8	12.5	TO-39
MRF559	870	0.063	0.5	9.0	12.5	317-1
MRF581	870	0.12	1.0	9.2	12.5	317-1

TABLE 7. High-Voltage Class C Amplifiers

Device Type	Frequency (MHz)	P_{in} (w)	P_{out} (w)	G_{pe} dB	Voltage (V)	Case Outline
2N3553	175	0.25	2.5	10.0	28.0	TO-39
MRF525*	400	0.001	0.02	13.0	26.0	TO-39
2N3866	400	0.1	1.0	10.0	28.0	TO-39
2N5160†	400	0.16	1.0	8.0	28.0	TO-39
MRF313	400	0.03	1.0	15.0	28.0	305A-1
MRF313A	400	0.03	1.0	15.0	28.0	305-1

*Grounded Emitter TO-39
†PNP

1

RF SMALL-SIGNAL TRANSISTORS (continued)

Small-Signal Amplifier Transistor Selection by Package

In small-signal RF applications the package style is often determined by the end application, or circuit construction technique. To aid the circuit designer in device selection, below are listed the Motorola broad range of RF small-signal amplifier transistors organized by package. Devices for other applications such as oscillators or switches are shown in the appropriate preceding tables.

TABLE 8. TO-39 METAL CAN

	Gain — BW		Noise Figure			Gain		Maximum Ratings		
Device Type	f_T GHz	I_C mA	NF dB	f MHz	I_C mA	dB Min	f MHz	$V_{(BR)CEO}$ V	I_C mA	P_T mW
MM8000	0.7	50	2.7	200	10	11.4*	200	30	0.4	3.50
MM8001	0.9	50	2.7	200	10	11.4*	200	30	0.4	3.50
2N5109	1.2	50	3.0	200	10	11	216	20	400	2.50
2N5943	1.2	50	3.4	200	30	11.4*	200	30	400	3.50
MRF525†	2.5	50	4.0	400	—	13	400	35**	150	2.50
MRF517	2.7	60	7.5	300	50	10*	300	35**	150	2.50
MRF586	4.5	70	3.0	500	70	14*	500	17	200	2.50

†Grounded Emitter TO-39 *Typ **$V_{(BR)CBO}$

TABLE 9. Plastic — SOE — Case 317-01/317A-01

	Gain — BW		Noise Figure			Gain		Maximum Ratings		
Device Type	f_T GHz	I_C mA	NF dB	f MHz	I_C mA	dB Min	f MHz	$V_{(BR)CEO}$ V	I_C mA	P_T mW
MRF931	3.0	1.0	3.8	500	0.25	16*	500	5.0	5.0	50
MRF559	3.0	100	—	—	—	13.0*	512	18	150	2000
BFW92A	4.0	25	2.5	500	2.0	16*	500	5.0	50	190
MRF901	4.5	15	2.0	1000	5.0	10	1000	15	30	375
BFR96	4.5	50	2.0*	500	10	12	500	15	100	500
MRF961	4.5	50	2.0*	500	10	13.5	500	15	100	500
MRF911	5.0	30	2.5	1000	5.0	12.5*	1000	12	40	400
BFR90	5.0	14	2.4	500	2.0	18*	500	15	30	180
BFR91	5.0	30	1.9	500	2.0	16*	500	12	35	180
MRF571	8.0	5.0	1.0*	500	5.0	13.5	500	10	70	2500
MRF580	5.0	75	2.0*	500	50.0	11.0	500	18	200	2500
MRF581	5.0	75	2.0*	500	50.0	13.0	500	18	200	2500
MRF536**	5.0	20	4.5*	1000	3.0	8.5	1000	10	30	300

*Typ **PNP

TABLE 10. Ceramic — SOE — Case 244A-01, 303-01, 358-01

	Gain — BW		Noise Figure			Gain		Maximum Ratings		
Device Type	f_T GHz	I_C mA	NF dB	f MHz	I_C mA	dB Min	f MHz	$V_{(BR)CEO}$ V	I_C mA	P_T mW
2N5947	1.5	75	3.8	200	50	10	250	30	400	5000
MRF511	2.1	80	7.3	200	50	10	250	25	250	5000
2N6603	4.5	15	2.0	1000	5.0	13*	1000	15	30	400
MRF962	4.5	50	2.0*	500	10	15	500	15	100	750
2N6604	5.0	30	2.5	1000	5.0	14	1000	12	50	500
MRF587	5.5	70	3.0	500	70	15*	500	17	200	5800
MRF572	8.0	50	2.0	1000	5.0	10	1000	10	70	2500
MRF573	8.0	50	2.0	1000	5.0	10	1000	10	70	2500

*Typ

RF SMALL-SIGNAL TRANSISTORS (continued)

TABLE 11. TO-72 METAL CAN

Device Type	Gain — BW f_T GHz	Gain — BW I_C mA	Noise Figure NF dB	Noise Figure f MHz	Noise Figure I_C mA	Gain dB Min	Gain f MHz	Maximum Ratings $V_{(BR)CEO}$ V	Maximum Ratings I_C mA	Maximum Ratings P_T mW
2N5031	1.0	5.0	2.5	450	1.0	14	450	10	20	200
2N5032	1.0	5.0	3.0	450	1.0	14	450	10	20	200
2N4958*	1.0	2.0	3.3	450	2.0	16	450	30	30	200
2N4959*	1.0	2.0	3.8	450	2.0	15	450	30	30	200
2N5829*	1.2	2.0	2.5	450	2.0	17	450	30	30	200
2N4957*	1.2	2.0	3.0	450	2.0	17	450	30	30	200
MRF501	1.2	5.0	4.0	200	1.5	15**	200	15	50	200
MRF502	1.2	5.0	4.0	200	1.5	15**	200	15	50	200
2N6305	1.2	10	5.5	450	2.0	12	450	15	50	200
BFX89	1.2	25	6.5	500	2.0	19	200	15	50	200
BFY90	1.4	25	5.0	500	2.0	21	200	15	50	200
2N5179	1.4	10	4.5	200	1.5	15	200	12	50	200
2N6304	1.4	10	4.5	450	2.0	15	450	15	50	200
2N3839	1.6	8.0	3.9	450	1.5	12.5	450	15	40	200
2N2857	1.6	8.0	4.1	450	1.5	12.5	450	15	40	200
MRF904	4.0	15	1.5	450	5.0	16	450	15	30	200
MRF914	4.5	20	2.0	500	5.0	15	500	12	40	200

*PNP **Typ

RF Amplifier Modules

The devices listed below are general purpose RF hybrid amplifiers, which feature input and output impedance matching and dc biasing networks for simplified RF amplifier design.

TABLE 12. General-Purpose 50 Ω — 100 Ω Wideband Modules

Device Type	Frequency Range MHz	Gain dB Min/Typ	Supply Voltage Vdc	Output Level 1 dB Compression mW/f (MHz)	Noise Figure @ 250 MHz dB
MHW590	10-400	32.5/34	24	800/200	5.0
MHW591	1.0-250	35/36.5	13.6	700/100	5.0
MHW592	1.0-250	34.5/36	24	900/100	5.0
MHW593	10-400	34/35.5	13.6	600/200	4.5

TABLE 13. TO-39 Wideband, 50 Ω Modules

The MWA Series features excellent gain versus frequency flatness, temperature stability and are cascadable for high gain lineups. Construction techniques include thin film gold metal circuitry and hermetic TO-39 package. MWA devices processed for military applications are available to special order.

Device Type	Frequency Range MHz	Gain dB Min/Typ	Supply Voltage Vdc	Output Level 1 dB Compression dBm Typ	Noise Figure (400 MHz) dB Typ
MWA110	0.1-400	13/14	2.9	−2.5	4.0
MWA120	0.1-400	13/14	5.0	+8.2	5.5
MWA130	0.1-400	13/14	5.5	+18	7.0
MWA210	0.1-600	9/10	1.75	+1.5	6.0
MWA220	0.1-600	9/10	3.2	+10.5	6.5
MWA230	0.1-600	9/10	4.4	+18.5	7.5
MWA310	0.1-1000	7/8	1.60	+3.5	6.5
MWA320	0.1-1000	7/8	2.9	+11.5	6.7
MWA330	0.1-1000	—/6.2	4.0	+15.2	9.0

1

RF SMALL-SIGNAL TRANSISTORS (continued)

High Reliability RF Transistors

The listed devices are active per QPL-19500 (Qualified Products List). Check with your local Motorola Sales Office or franchised Distributor for current qualification status and additions.

2N2857JAN 2N2857JTX 2N2857JTXV	2N4957JAN 2N4957JTX 2N4957JTXV
2N3553JAN 2N3553JTX 2N3553JTXV	2N5109JAN 2N5109JTX 2N5109JTXV
2N3866JAN 2N3866JTX 2N3866JTXV	2N6603JAN 2N6603JTX 2N6603JTXV
2N3866AJAN 2N3866AJTX 2N3866AJTXV	2N6604JAN 2N6604JTX 2N6604JTXV
2N3960JAN 2N3960JTX 2N3906JTXV	

Transistor Complements

The transistor complements listed are suitable for most applications requiring NPN and PNP devices of similar RF characteristics. If your application demands special matching of complementary transistors, please contact your local Motorola Sales Office or Motorola distributors.

NPN	PNP
2N2857	2N4958
2N3553	MM4019
2N3866	2N5160
2N3959, 2N3960	2N4260, 2N4261
2N3906JAN	MM4261H
2N5943	2N5583
MRF531	MRF532
MRF904	MM4049
MRF571	MRF536

Devices for Hi-Rel Applications

In addition to CECC 50 000 Qualified Devices listed on page 1-25, Motorola offers over 650 devices listed in QPL-19500, and is certified to supply small-signal bipolar devices to ALL FOUR quality levels of MIL-S-19500: JAN, JANTX, JANTXV, and JANS.

Refer also to section 9 for Quality Assurance Processing Information.

Switching and High-Frequency Transistors

Device	MIL-S-19500
2N703 JAN	153
2N706 JAN	120
2N708 JAN,JTX	312
2N718A JAN,JTX,JTXV	/181
2N869A JAN,JTX	/283
2N914 JAN,JTX	/373
2N916 JAN	/271
2N918 JAN,JTX,JTXV,JANS	301
2N929 JAN,JTX	/253
2N930 JAN,JTX	/253
2N1132 JAN	177
2N1613 JAN,JTX,JTXV	181
2N2218 JAN,JTX,JTXV	251
2N2218A JAN,JTX,JTXV	251
2N2219 JAN,JTX,JTXV	251
2N2219A JAN,JTX,JTXV	251
2N22219AL JANS	/
2N2221 JAN,JTX,JTXV	/255
2N2221A JAN,JTX,JTXV	/255
2N2222 JAN,JTX,JTXV	255
2N2222A JAN,JTX,JTXV,JANS	/225
2N2369A JAN,JTX,JTXV,JANS	/317
2N2481 JAN,JTX	/268
2N2904 JAN,JTX,JTXV	/290
2N2905 JAN,JTX,JTXV	/290
2N2905A JAN,JTX,JTXV	/290
2N2905AL JANS	/
2N2906 JAN,JTX,JTXV	/291
2N2906A JAN,JTX,JTXV	/291
2N2907 JAN,JTX,JTXV	/291
2N2907A JAN,JTX,JTXV,JANS	/291
2N2944A JAN,JTX,JTXV	/
2N2945A JAN,JTX,JTXV	/
2N2946A JAN,JTX,JTXV	/
2N3013 JAN,JTX	/287
2N3019,S JAN,JTX,JTXV	/391
2N3250A JAN,JTX,JTXV	/323
2N3251A JAN,JTX,JTXV	/323
2N3253 JAN	/347
2N3444 JAN	/347
2N3467 JAN,JTX,JTXV	/348
2N3468 JAN,JTX,JTXV	/348
2N3485A JAN,JTX	/392
2N3486A JAN,JTX	/392
2N3498 JAN,JTX,JTXV	/366
2N3499 JAN,JTX,JTXV	/366
2N3500 JAN,JTX,JTXV	/366
2N3501 JAN,JTX,JTXV	/366
2N3506 JAN,JTX,JTXV	/349
2N3507 JAN,JTX,JTXV	/349
2N3634 JAN,JTX,JTXV	/357
2N3635 JAN,JTX,JTXV	/357
2N3636 JAN,JTX,JTXV	/357
2N3637 JAN,JTX,JTXV	/357
2N3700 JAN,JTX,JTXV	/391
2N3735 JAN,JTX,JTXV	/395
2N3737 JAN,JTX,JTXV	/395
2N3743 JAN,JTX,JTXV	/397
2N3762 JAN,JTX,JTXV	/396
2N3763 JAN,JTX,JTXV	/396
2N3764 JAN,JTX,JTXV	/396
2N3765 JAN,JTX,JTXV	/396
2N4033 JAN,JTX,JTXV	/511
2N4261 JAN,JTX	/511
2N4405 JAN,JTX	/488
2N4449 JAN,JTX,JTXV	/317
2N4453 JAN,JTX	/283
2N4930 JAN,JTX,JTXV	/397
2N4931 JAN,JTX,JTXV	/397
2N5581 JAN,JTX	/423
2N5582 JAN,JTX	/423

RF Transistors

Device	MIL-S-19500
2N918 JAN,JTX,JTXV,JANS	/301
2N2857 JAN,JTX,JTXV	/343
2N3375 JAN,JTX,JTXV	/341
2N3553 JAN,JTX,JTXV	/341
2N3866 JAN,JTX,JTXV	/398
2N3866A JAN,JTX,JTXV	/398
2N3959 JAN,JTX,JTXV	/399
2N3960 JAN,JTX,JTXV	/399
2N4957 JAN,JTX,JTXV	/426
2N5109 JAN,JTX,JTXV	/453
2N6603 JAN,JTXV	/522
2N6604 JAN,JTXV	/522

Multiple Devices

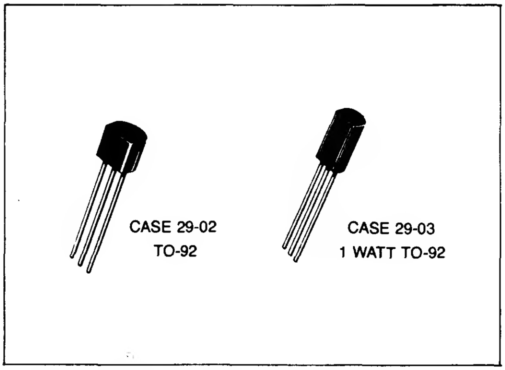
Device	MIL-S-19500
2N2060 JAN,JTX,JTXV	/270
2N2919 JAN,JTX,JTXV	/355
2N2920 JAN,JTX,JTXV	/355
2N3810 JAN,JTX,JTXV	/336
2N3811 JAN,JTX,JTXV	/336
2N4854 JAN,JTX,JTXV	/421
2N5793 JAN,JTX,JTXV	/495
2N5794 JAN,JTX,JTXV	/495
2N5795 JAN,JTX,JTXV	/496
2N5796 JAN,JTX,JTXV	/496

Field-Effect Transistors

Device	MIL-S-19500
2N2608 JAN	/295
2N2609 JAN	/296
2N3330 JAN,JTX	/378
2N3821 JAN,JTX,JTXV	/375
2N3822 JAN,JTX,JTXV	/375
2N3823 JAN,JTX,JTXV	/375
2N4856 JAN,JTX,JTXV	/385
2N4857 JAN,JTX,JTXV	/385
2N4858 JAN,JTX,JTXV	/385
2N4859 JAN,JTX,JTXV	/385
2N4860 JAN,JTX,JTXV	/385
2N4861 JAN,JTX,JTXV	/385
2N4091 JAN,JTX,JTXV	/431
2N4092 JAN,JTX,JTXV	/431
2N4093 JAN,JTX,JTXV	/431

Plastic-Encapsulated Small-Signal Transistors

2



Motorola's small-signal TO-92 plastic transistors encompass hundreds of devices spanning the gamut from general-purpose amplifiers and switches with a wide variety of characteristics to dedicated special-purpose devices for the most demanding applications. The popular high-volume TO-92 package combines proven reliability, performance, economy and convenience to provide the perfect solution for industrial and consumer design problems.

As an additional service to our customers Motorola will, upon request, supply the following:

- Radial tape and reel
- Axial tape and reel
- TO-5 lead forming
- TO-18 lead forming

Contact your Motorola representative for ordering information.

2

2N3903
2N3904

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltge	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
*Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

***THERMAL CHARACTERISTICS**

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

*Indicates Data in addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 3.0$ Vdc)		I_{BL}	—	50	nAdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 3.0$ Vdc)		I_{CEX}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3903 2N3904		20 40	— —	
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3903 2N3904		35 70	— —	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3903 2N3904		50 100	150 300	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3903 2N3904		30 60	— —	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3903 2N3904		15 30	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	— —	0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	0.65 —	0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	2N3903 2N3904	f_T	250 300	— —	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903 2N3904	h_{ie}	1.0 1.0	8.0 10	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903 2N3904	h_{re}	0.1 0.5	5.0 8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903 2N3904	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)	2N3903 2N3904	NF	— —	6.0 5.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	2N3903 2N3904	t_s	— —	175 200	ns
Fall Time			t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

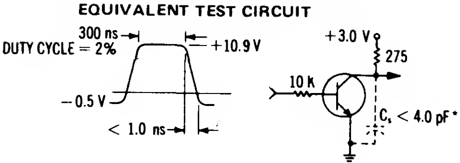
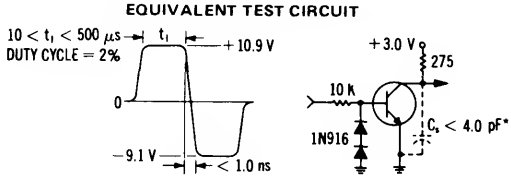


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

— T_J = 25°C - - - T_J = 125°C

FIGURE 3 – CAPACITANCE

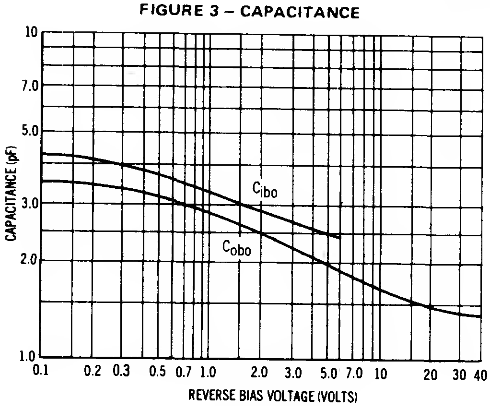


FIGURE 4 – CHARGE DATA

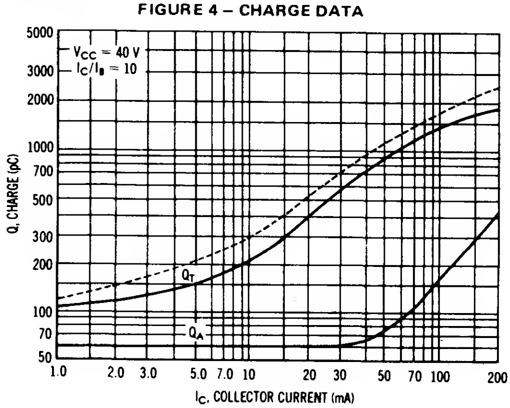


FIGURE 5 — TURN-ON TIME

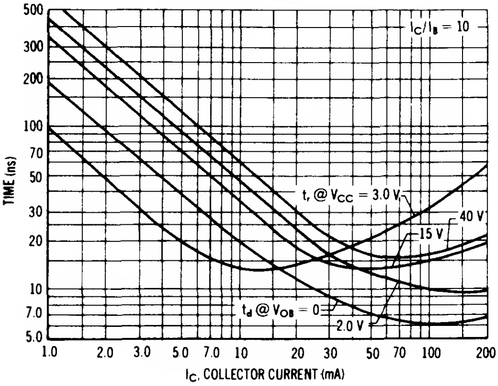


FIGURE 6 — RISE TIME

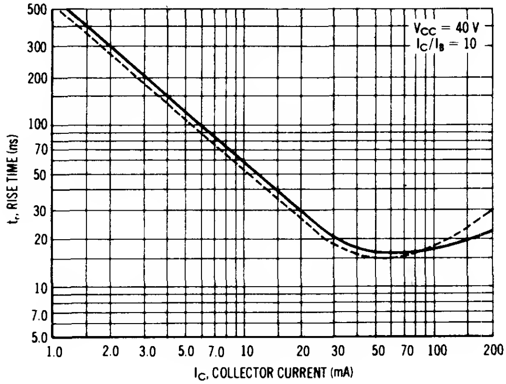


FIGURE 7 — STORAGE TIME

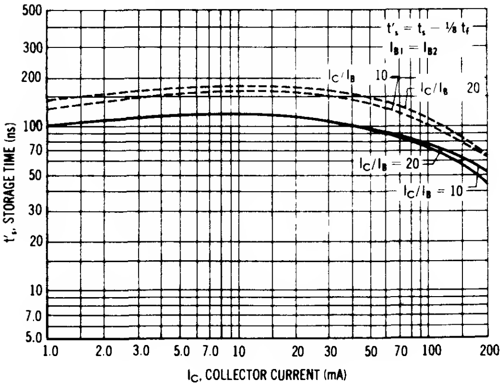
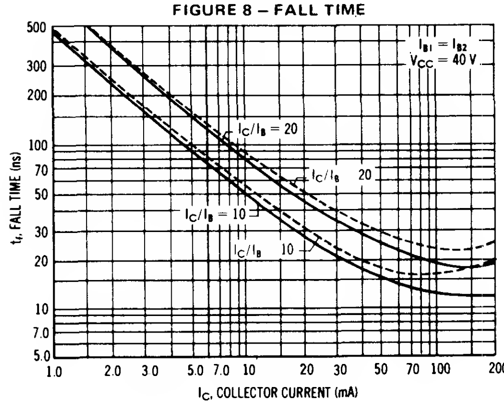


FIGURE 8 — FALL TIME



TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C,
Bandwidth = 1.0 Hz

FIGURE 9

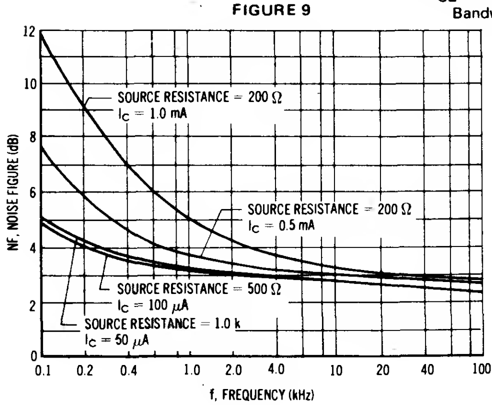
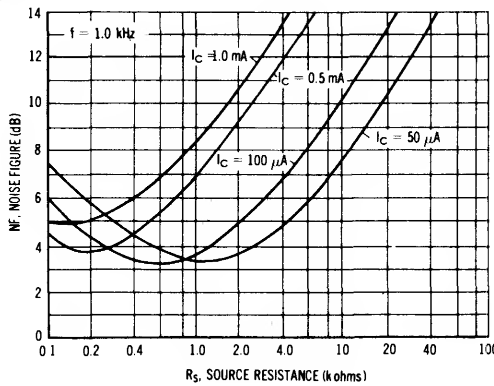


FIGURE 10



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 11 – CURRENT GAIN

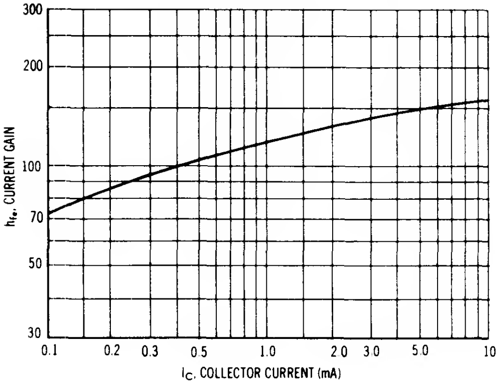


FIGURE 12 – OUTPUT ADMITTANCE

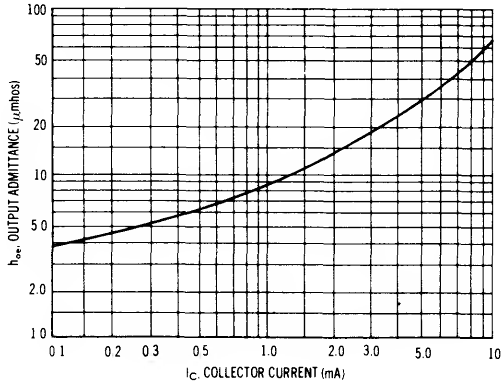


FIGURE 13 – INPUT IMPEDANCE

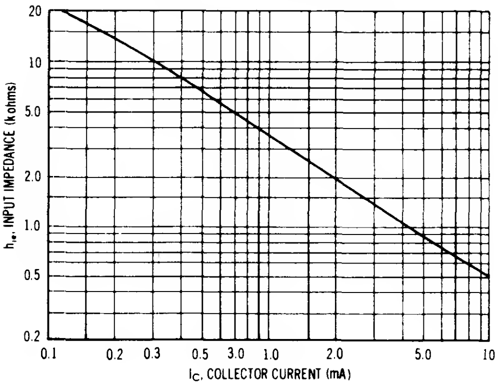
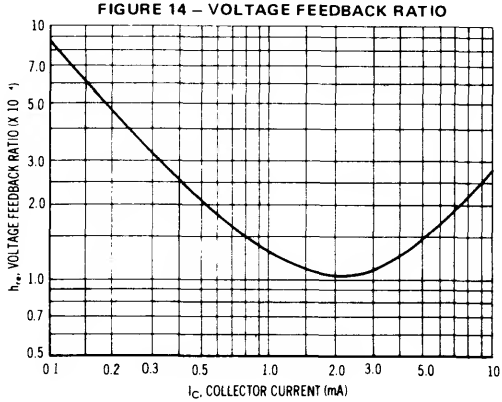


FIGURE 14 – VOLTAGE FEEDBACK RATIO



TYPICAL STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

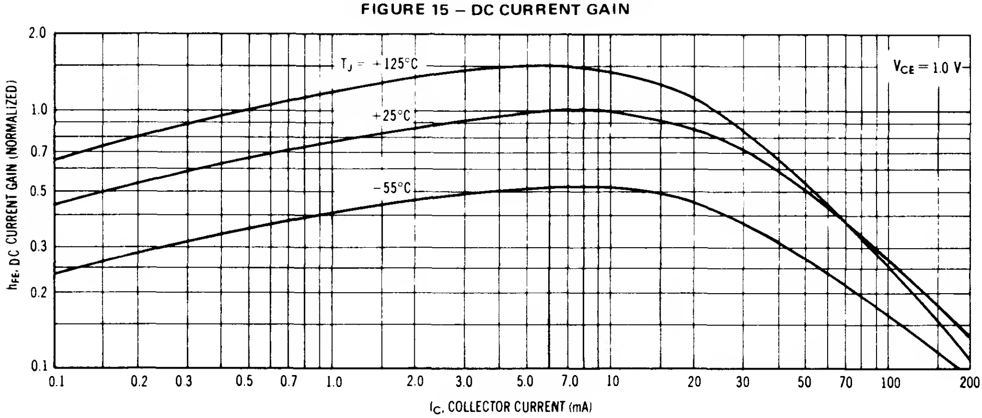


FIGURE 16 – COLLECTOR SATURATION REGION

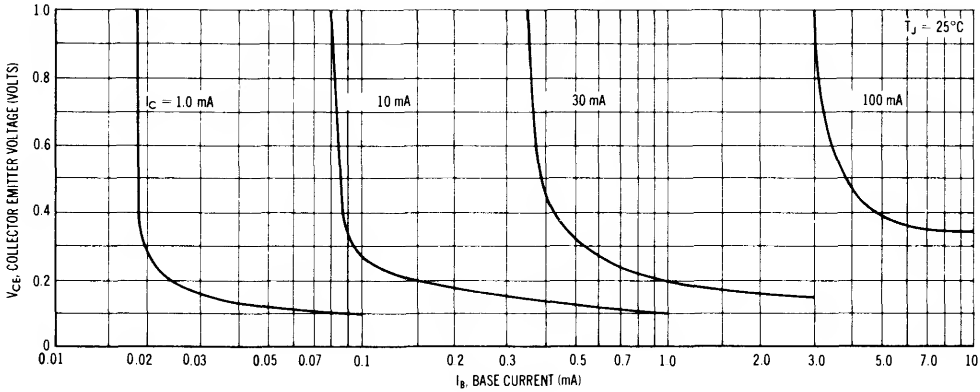


FIGURE 17 – "ON" VOLTAGES

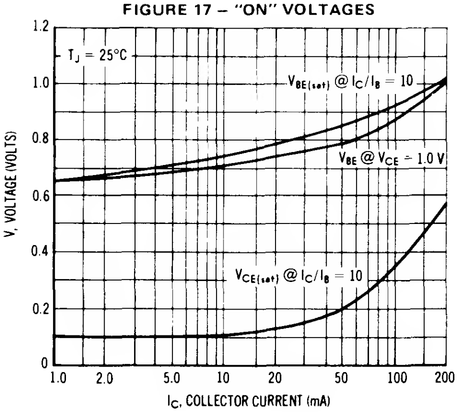
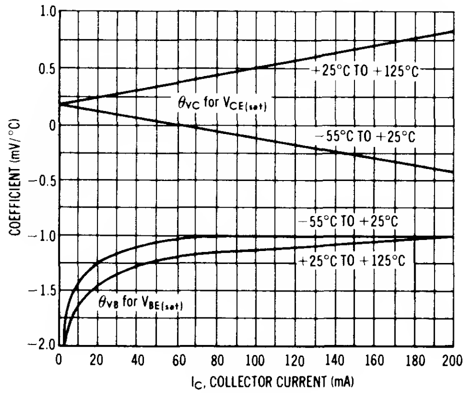


FIGURE 18 – TEMPERATURE COEFFICIENTS



2N3905
2N3906

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ T_A = 60°C	P_D	250	mW
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)		I_{BL}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)		I_{CEX}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3905 2N3906	h_{FE}	30 60	— —	—
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3905 2N3906		40 80	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3905 2N3906		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3905 2N3906		30 60	— —	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3905 2N3906		15 30	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	— —	0.25 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	0.65 —	0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3905 2N3906	f_T	200 250	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	10.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{ie}	0.5 2.0	8.0 12	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{re}	0.1 0.1	5.0 10	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{oe}	1.0 3.0	40 60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)	2N3905 2N3906	NF	— —	5.0 4.0	dB

SWITCHING CHARACTERISTICS

			Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	2N3905 2N3906	t_s	— —	200 225	ns
Fall Time		2N3905 2N3906	t_f	— —	60 75	ns

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

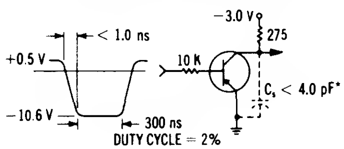
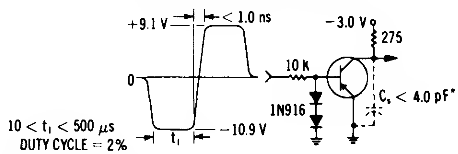


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

—— T_J = 25°C - - - T_J = 125°C

FIGURE 3 — CAPACITANCE

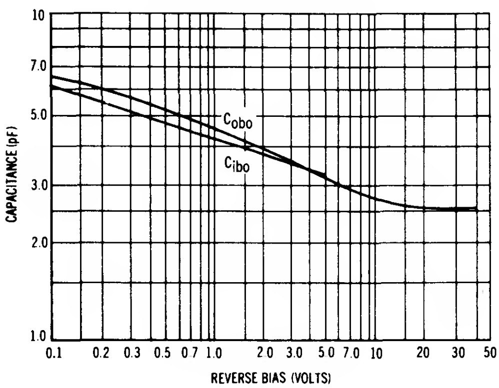


FIGURE 4 — CHARGE DATA

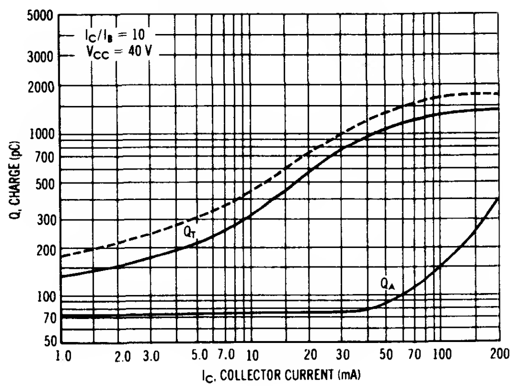


FIGURE 5 — TURN-ON TIME

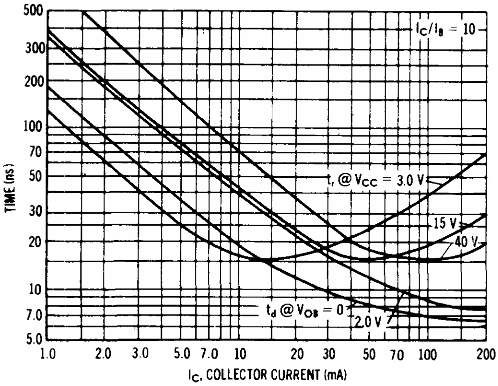
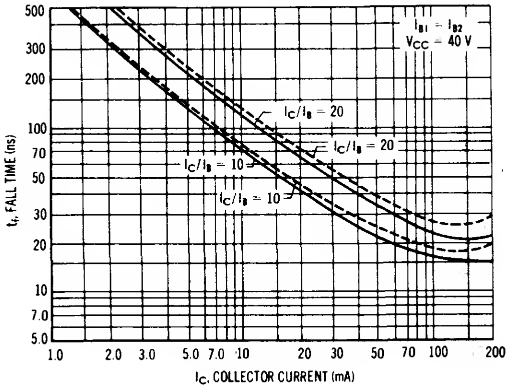


FIGURE 6 — FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

$V_{CE} = 5.0$ Vdc, $T_A = 25^{\circ}C$,
Bandwidth = 1.0 Hz

FIGURE 7 —

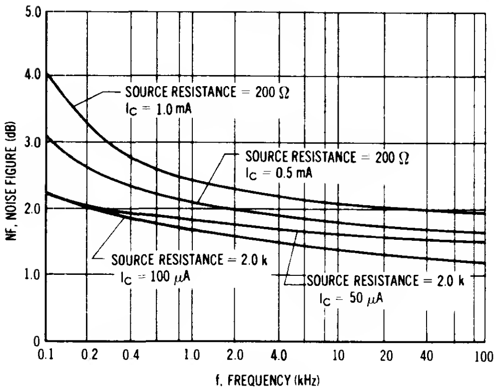
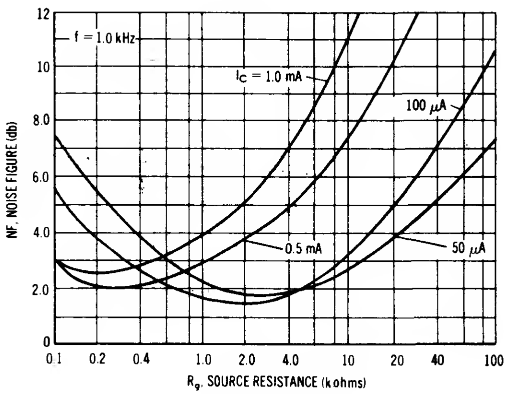


FIGURE 8 —



h PARAMETERS

($V_{CE} = 10$ Vdc, f = 1.0 kHz, $T_A = 25°C$)

FIGURE 9 — CURRENT GAIN

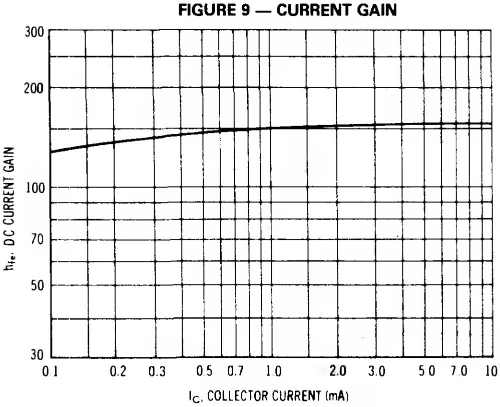


FIGURE 10 — OUTPUT ADMITTANCE

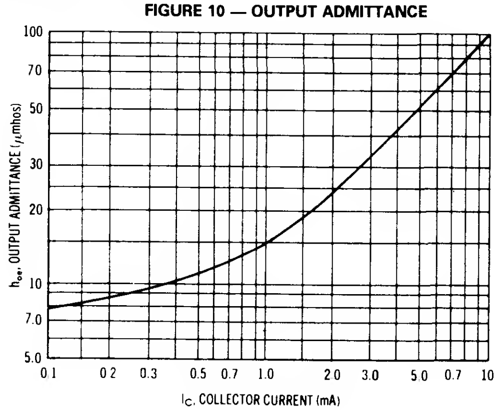


FIGURE 11 — INPUT IMPEDANCE

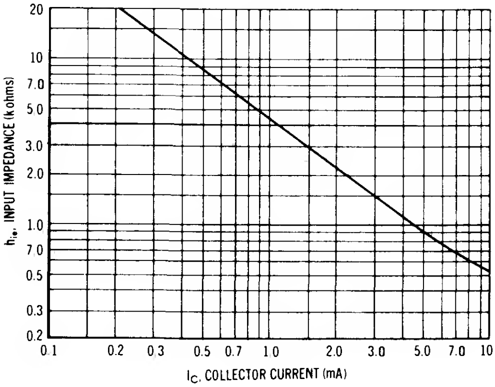
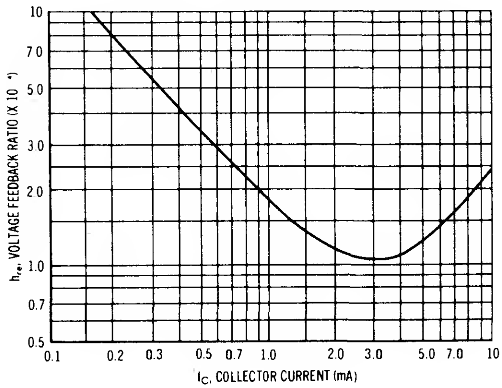


FIGURE 12 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 13 — DC CURRENT GAIN

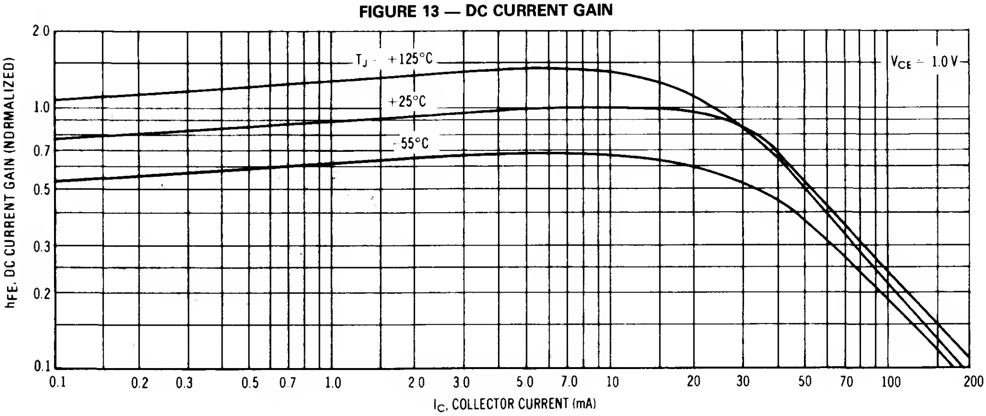


FIGURE 14 — COLLECTOR SATURATION REGION

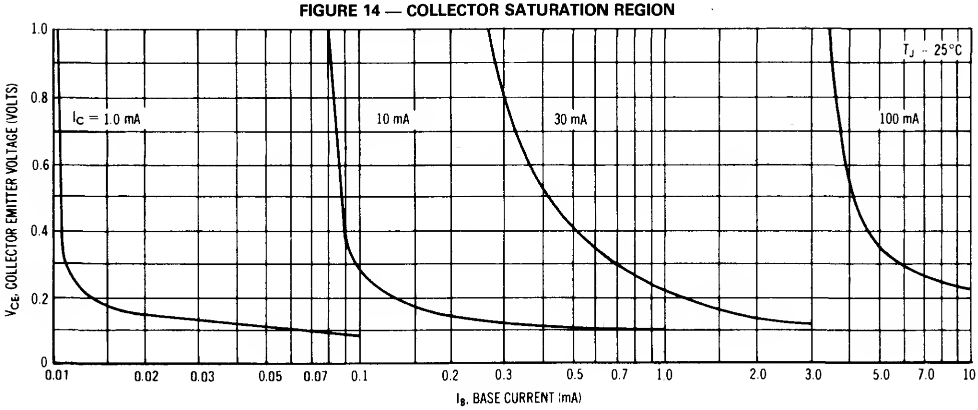


FIGURE 15 — "ON" VOLTAGES

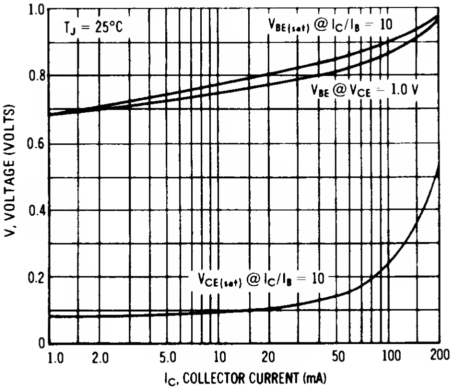
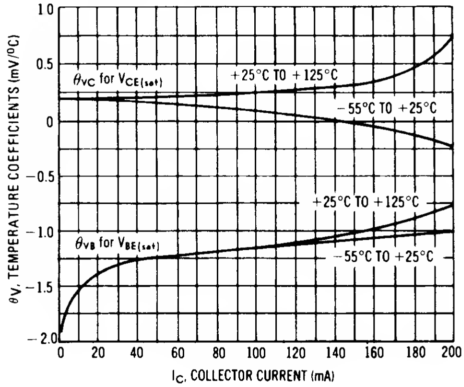


FIGURE 16 — TEMPERATURE COEFFICIENTS



2

2N4123
2N4124

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4123	2N4124	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	40	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_E = 0$)	 2N4123 2N4124	$V_{(BR)CEO}$	 30 25	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	 2N4123 2N4124	$V_{(BR)CBO}$	 40 30	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 2.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	 2N4123 2N4124 2N4123 2N4124	h_{FE}	 50 120 25 60	 150 360 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	 2N4123 2N4124	f_T	 250 300	 — —	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 MHz)		C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	8.0	pF
Collector-Base Capacitance ($I_E = 0$, $V_{CB} = 5.0$ V, f = 100 kHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	 2N4123 2N4124	h_{fe}	 50 120	 200 480	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Current Gain — High Frequency		$\|h_{fe}\|$			—
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123		2.5	—	
	2N4124		3.0	—	
(I_C = 2.0 mAdc, V_{CE} = 10 V, f = 1.0 kHz)	2N4123		50	200	
(I_C = 2.0 mAdc, V_{CE} = 10 V, f = 1.0 kHz)	2N4124		120	480	
Noise Figure		NF			dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohm,	2N4123		—	6.0	
Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4124		—	5.0	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — CAPACITANCE

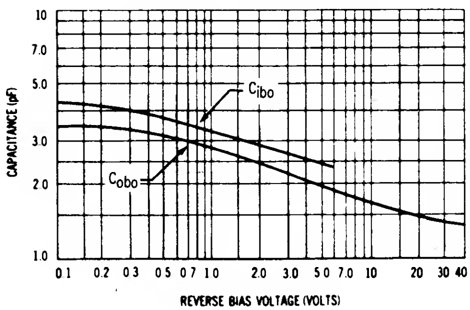
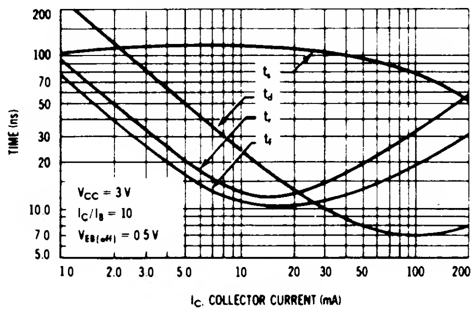


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

(V_{CE} = 5 Vdc, T_A = 25°C)
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

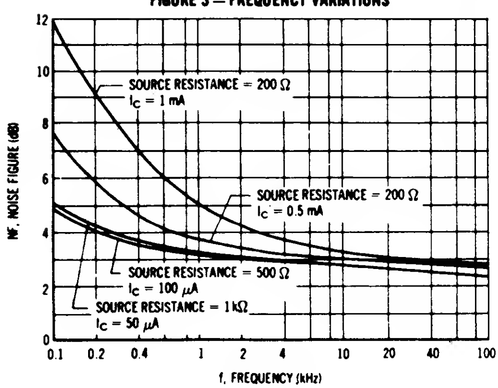
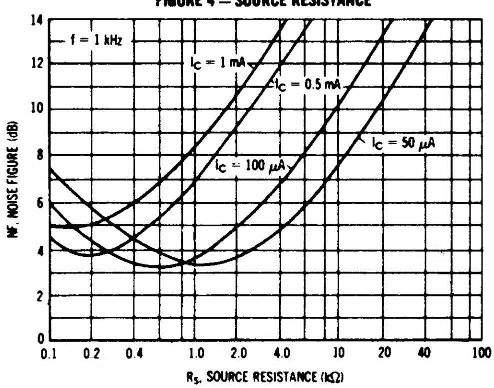


FIGURE 4 — SOURCE RESISTANCE



2

h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

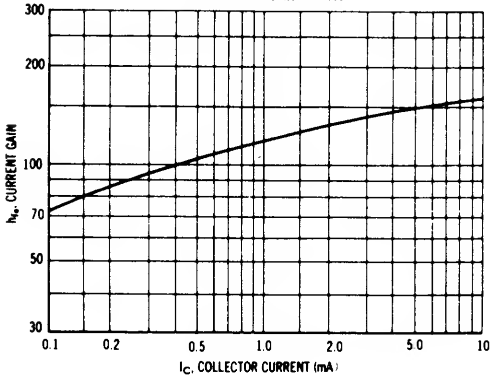


FIGURE 6 — OUTPUT ADMITTANCE

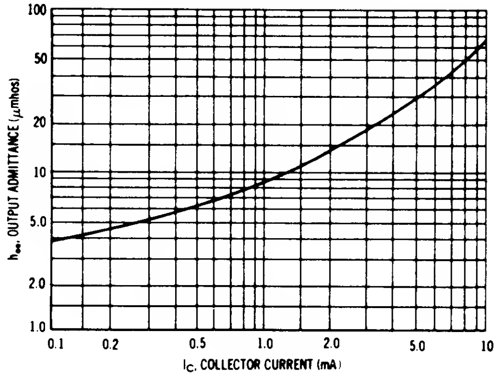


FIGURE 7 — INPUT IMPEDANCE

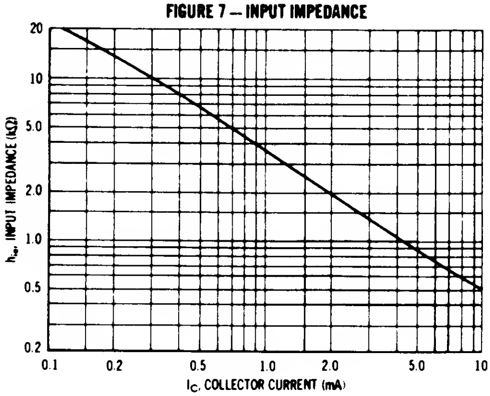
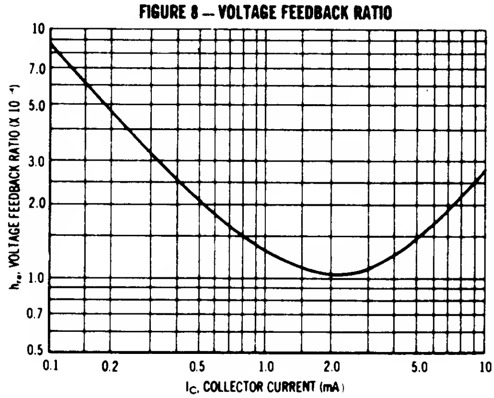


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 — DC CURRENT GAIN

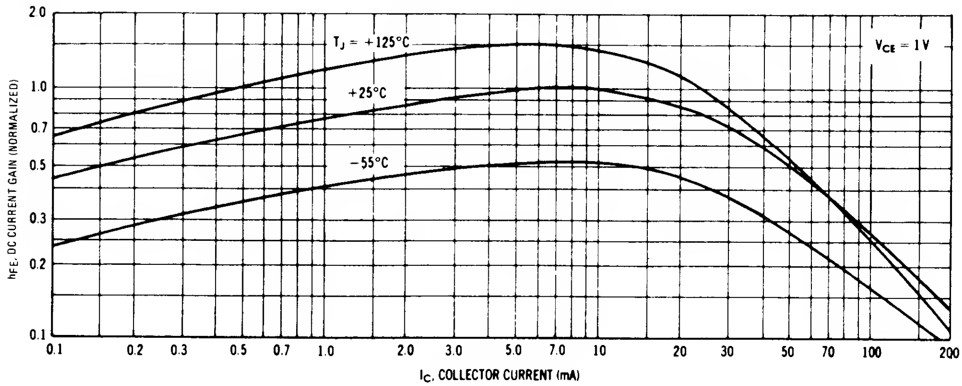


FIGURE 10 — COLLECTOR SATURATION REGION

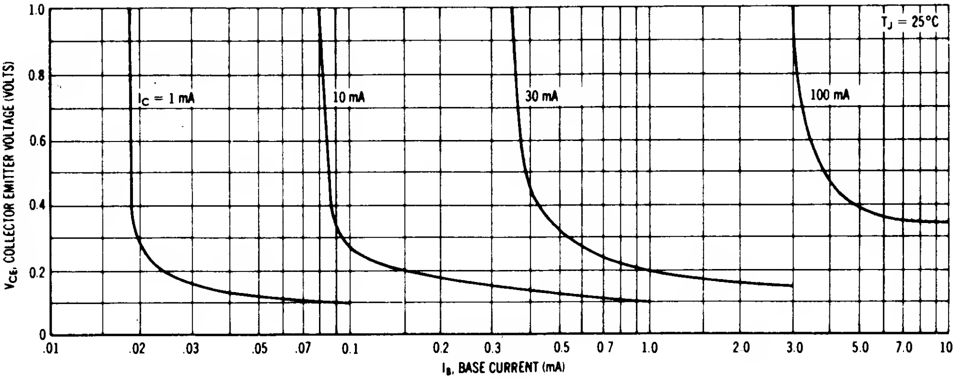


FIGURE 11 — "ON" VOLTAGES

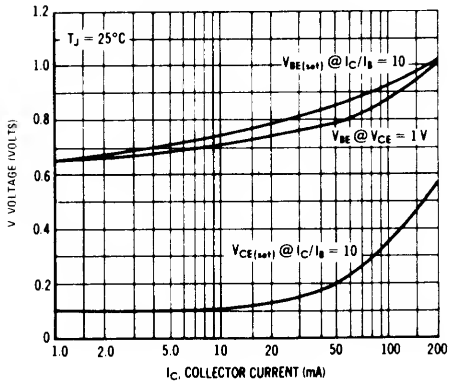
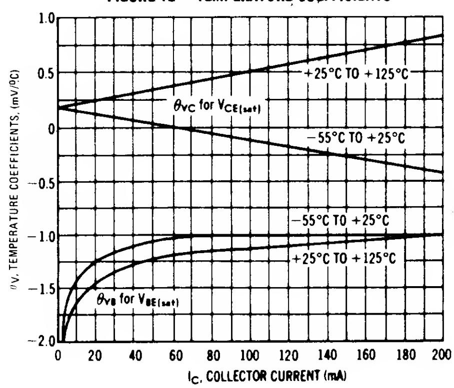


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4125
2N4126

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	30	25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_E = 0$)	2N4125 2N4126	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	2N4125 2N4126	$V_{(BR)CBO}$	30 25	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 2.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	 2N4125 2N4126 2N4125 2N4126	h_{FE}	 50 120 25 60	 150 360 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	 2N4125 2N4126	f_T	 200 250	 — —	MHz
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	10	pF
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	4.5	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	 2N4125 2N4126	h_{fe}	 50 120	 200 480	—
Current Gain — High Frequency ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	 2N4125 2N4126	$\|h_{fe}\|$	 2.0 2.5	 — —	—
Noise Figure ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_G = 1.0$ k ohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	 2N4125 2N4126	NF	 — —	 5.0 4.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle = 2.0%.

FIGURE 1 — CAPACITANCE

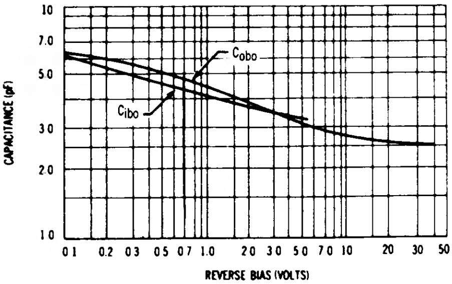
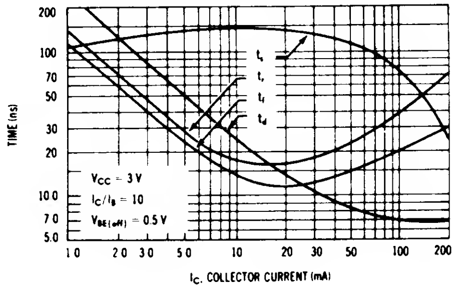


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 5.0 Vdc, T_A = 25°C,
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

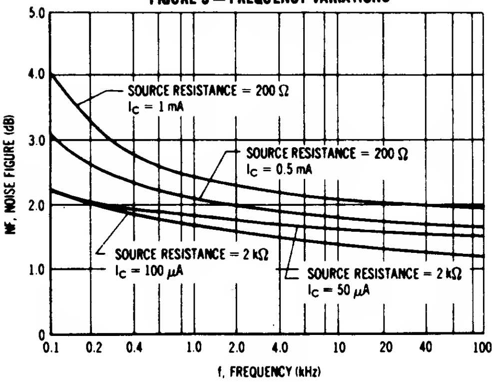
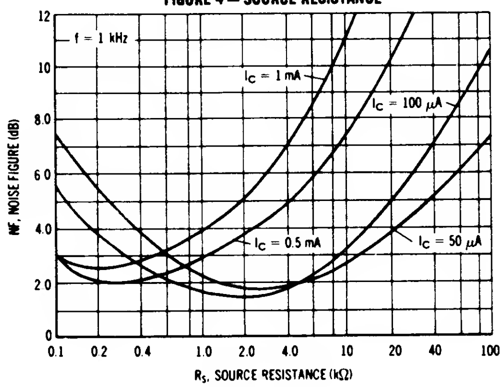


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

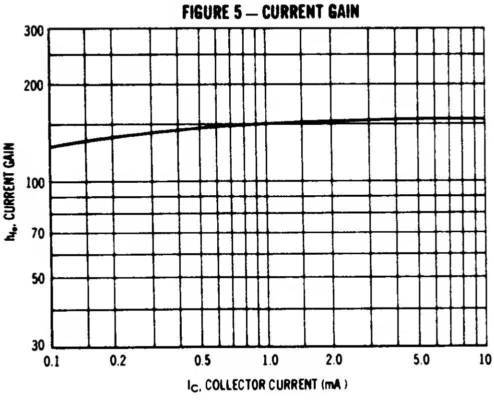


FIGURE 6 — OUTPUT ADMITTANCE

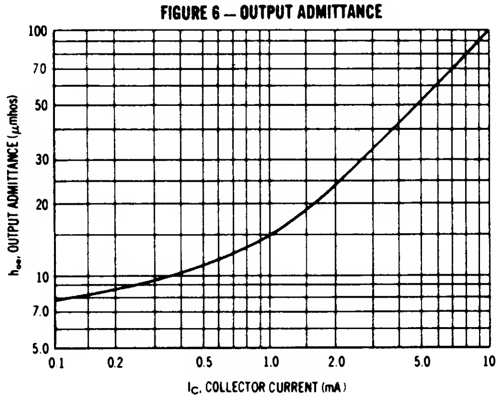


FIGURE 7 — INPUT IMPEDANCE

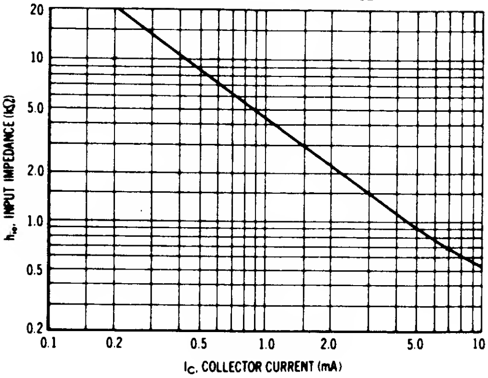
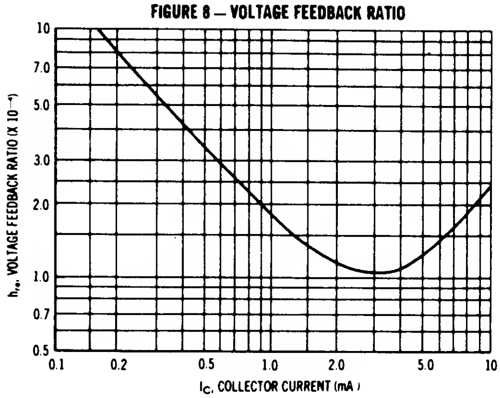


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 — DC CURRENT GAIN

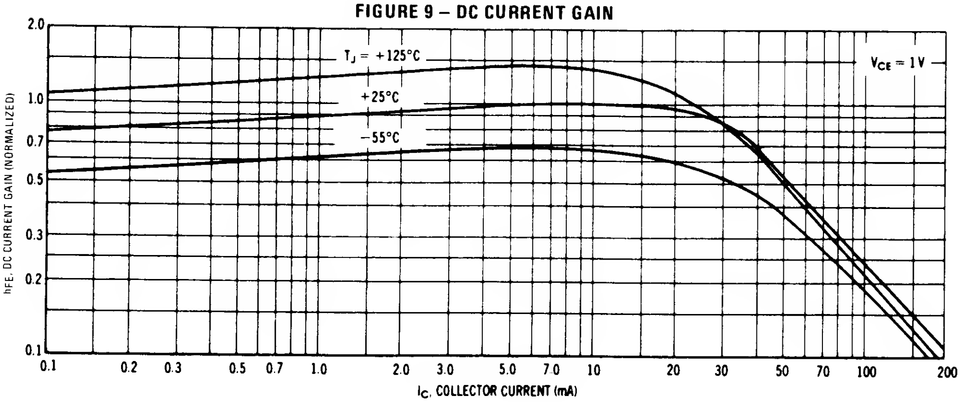


FIGURE 10 — COLLECTOR SATURATION REGION

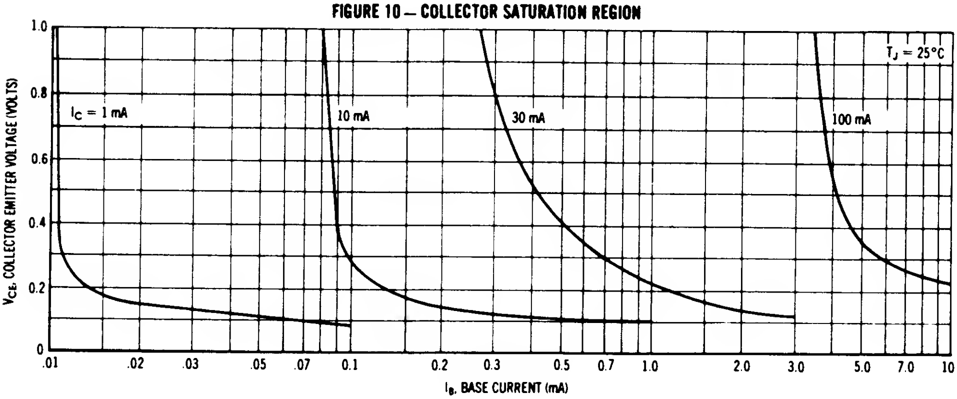


FIGURE 11 — "ON" VOLTAGES

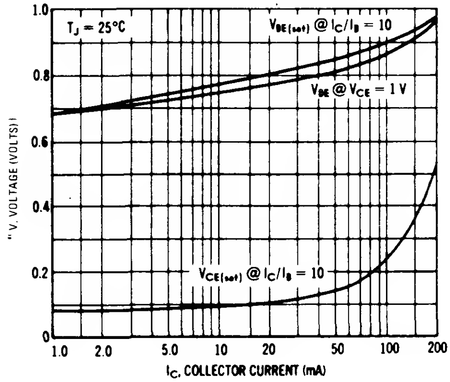
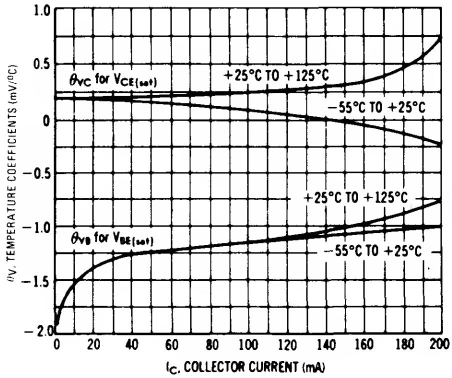


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4264
2N4265

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N4264	2N4265	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_E = 0$)	2N4264 2N4265	$V_{(BR)CEO}$	15 12	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 12$ Vdc, $V_{EB(off)} = 0.25$ Vdc) ($V_{CE} = 12$ Vdc, $V_{EB(off)} = 0.25$ Vdc, $T_A = 100°C$)		I_{BEV}	— —	0.1 10	μAdc
Collector Cutoff Current ($V_{CE} = 12$ Vdc, $V_{EB(off)} = 0.25$ Vdc)		I_{CEX}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4264 2N4265	h_{FE}	25 30	— —	—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4264 2N4265		40 100	160 400	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)	2N4264 2N4265		20 45	— —	
($I_C = 30$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4264 2N4265		40 90	— —	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	2N4264 2N4265		30 55	— —	
($I_C = 200$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	2N4264 2N4265		20 35	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)(1)		$V_{CE(sat)}$	— —	0.22 0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)(1)		$V_{BE(sat)}$	0.65 0.75	0.80 0.95	Vdc

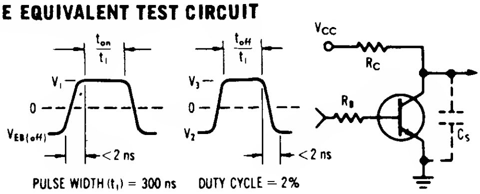
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	350	—	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	4.0	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 10 Vdc, $V_{EB(off)}$ = 2.0 Vdc, I_C = 100 mAdc, I_{B1} = 10 mAdc) (Fig. 1, Test Condition C)	t_d	—	8.0	ns
Rise Time		t_r	—	15	ns
Storage Time	V_{CC} = 10 Vdc, (I_C = 10 mAdc, for t_s) (I_C = 100 mA for t_f) I_{B1} = I_{B2} = 10 mAdc) (Fig. 1, Test Condition C)	t_s	—	20	ns
Fall Time		t_f	—	15	ns
Turn-On Time	(V_{CC} = 3.0 Vdc, $V_{EB(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc) (Fig. 1, Test Condition A)	t_{on}	—	25	ns
Turn-Off Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc) (Fig. 1, Test Condition A)	t_{off}	—	35	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 10 mA I_{B1} = I_{B2} = 10 mAdc) (Fig. 1, Test Condition A)	t_s	—	20	ns
Total Control Charge	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_B = mAdc) (Fig. 1, Test Condition B)	Q_T	—	80	pC

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — SWITCHING TIME EQUIVALENT TEST CIRCUIT

TEST CONDITION	I_C	V_{CC}	R_B	R_C	$C_{S(max)}$	$V_{EB(off)}$	V_1	V_2	V_3
	mA	V	Ω	Ω	pF	V	V	V	V
A	10	3	3300	270	4	−1.5	10.55	−4.15	10.70
B	10	10	560	960	4	—	—	−4.65	6.55
C	100	10	560	96	12	−2.0	6.35	−4.65	6.55



2

CURRENT GAIN CHARACTERISTICS

FIGURE 2 — MINIMUM CURRENT GAIN

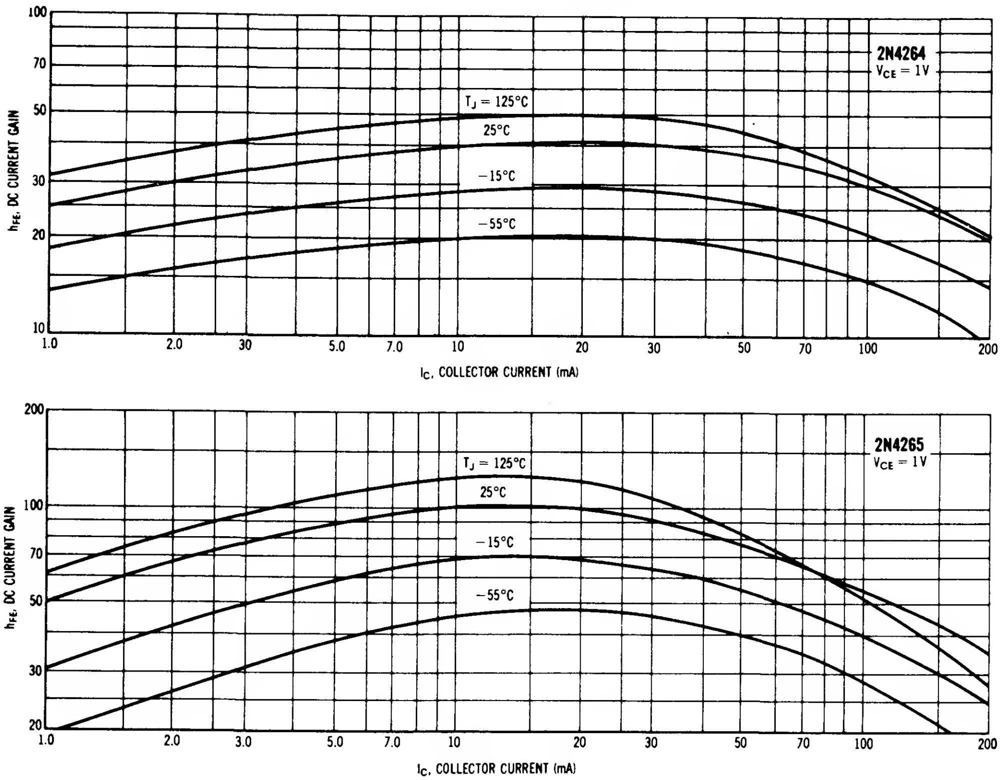


FIGURE 3 — Q_T TEST CIRCUIT

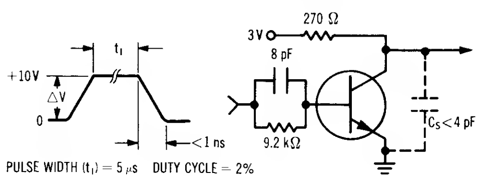
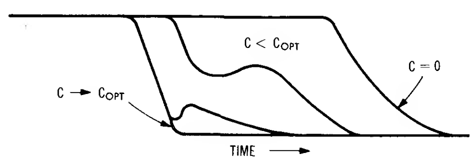


FIGURE 4 — TURN-OFF WAVEFORM



NOTE 1

When a transistor is held in a conductive state by a base current, I_B, a charge, Q_S, is developed or "stored" in the transistor. Q_S may be written: $Q_S = Q_I + Q_V + Q_X$.

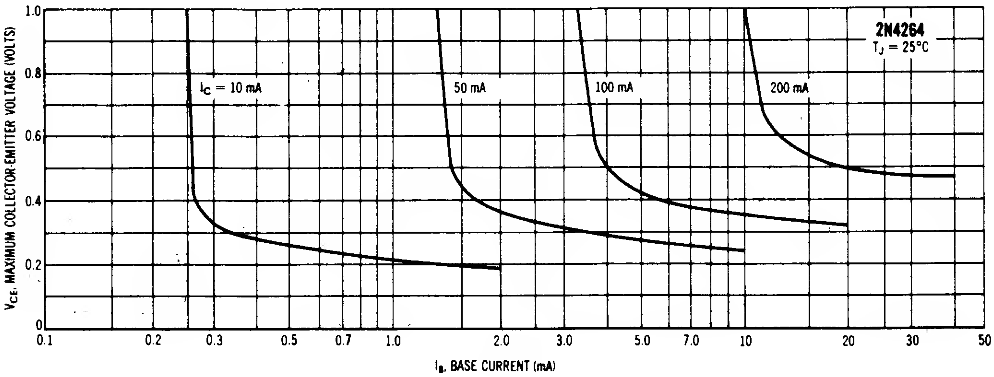
Q_I is the charge required to develop the required collector current. This charge is primarily a function of alpha cutoff frequency. Q_V is the charge required to charge the collector-base feedback capacity. Q_X is excess charge resulting from overdrive, i.e., operation in saturation.

The charge required to turn a transistor "on" to the edge of saturation is the sum of Q_I and Q_V which is defined as the active region charge, Q_A. $Q_A = I_{B1}t_r$ when the transistor is driven by a constant current step (I_{B1}) and $I_{B1} << \frac{I_C}{h_{FE}}$.

If I_B were suddenly removed, the transistor would continue to conduct until Q_S is removed from the active regions through an external path or through internal recombination. Since the internal recombination time is long compared to the ultimate capability of a transistor, a charge, Q_T, of opposite polarity, equal in magnitude, can be stored on an external capacitor, C, to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Figure 3 shows the test circuit and Figure 4 the turn-off waveform. Given Q_T from Figure 13, the external C for worst-case turn-off in any circuit is: $C = Q_T/\triangle V$, where $\triangle V$ is defined in Figure 3.

"ON" CONDITION CHARACTERISTICS

FIGURE 5 — COLLECTOR SATURATION REGION



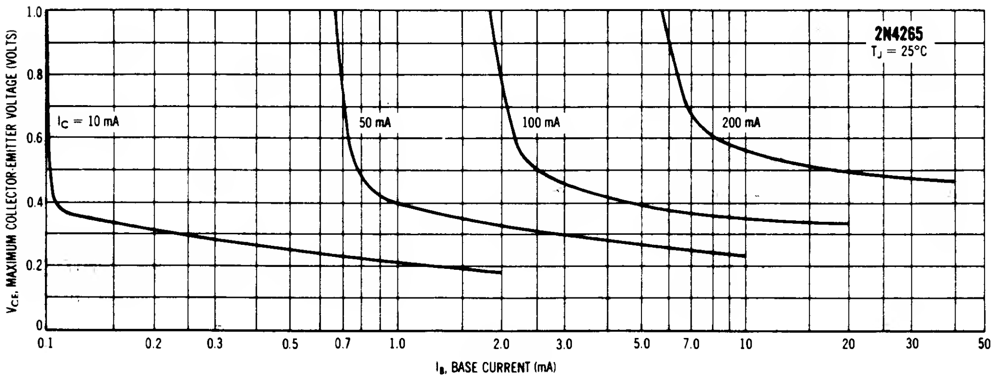


FIGURE 6 — SATURATION VOLTAGE LIMITS

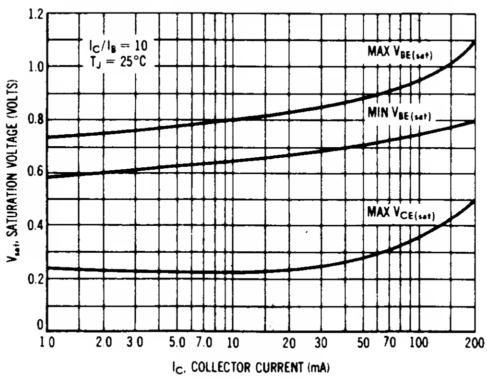
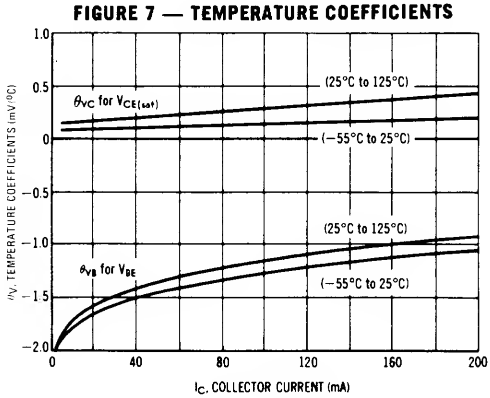


FIGURE 7 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 8 — DELAY TIME

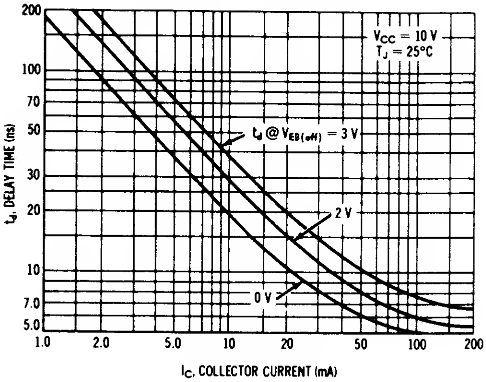


FIGURE 9 — RISE TIME

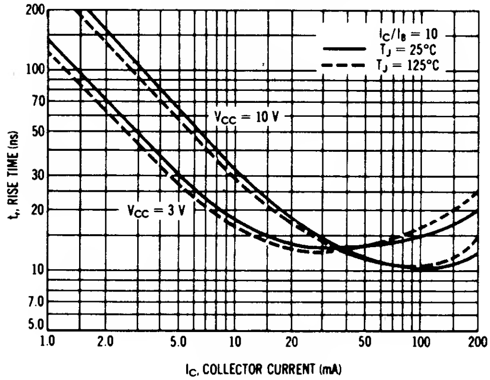


FIGURE 10 — STORAGE TIME

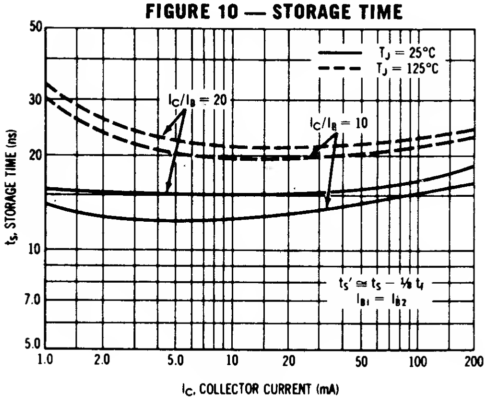


FIGURE 11 — FALL TIME

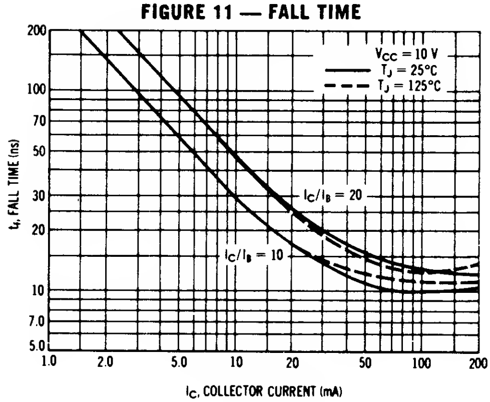


FIGURE 12 — JUNCTION CAPACITANCE

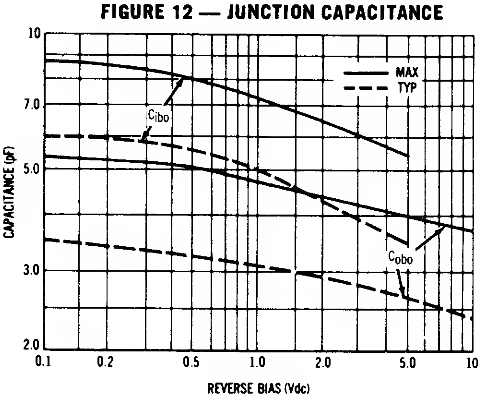
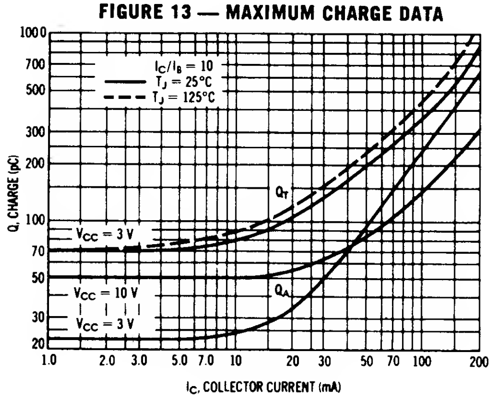


FIGURE 13 — MAXIMUM CHARGE DATA



2

2N4400
2N4401

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 35 Vdc, V_{EB} = 0.4 Vdc)		I_{BEV}	—	0.1	μAdc
Collector Cutoff Current (V_{CE} = 35 Vdc, V_{EB} = 0.4 Vdc)		I_{CEX}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N4401		20	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N4400 2N4401		20 40	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4400 2N4401		40 80	— —	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N4400 2N4401		50 100	150 300	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N4400 2N4401		20 40	— —	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	 — —	 0.4 0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	 0.75 —	 0.95 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz).	2N4400 2N4401	f_T	200 250	— —	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	—	6.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	—	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4400	h_{ie}	0.5	7.5	k ohms
	2N4401		1.0	15	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4400	h_{fe}	20	250	—
	2N4401		40	500	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	30	μmhos

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, V_{EB} = 2.0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

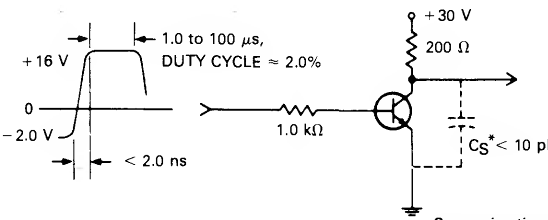
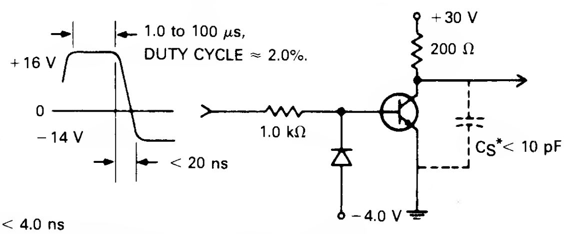


FIGURE 2 — TURN-OFF TIME



Scope rise time < 4.0 ns
*Total shunt capacitance of test jig connectors, and oscilloscope

TRANSIENT CHARACTERISTICS

——— 25°C – – – 100°C

FIGURE 3 — CAPACITANCES

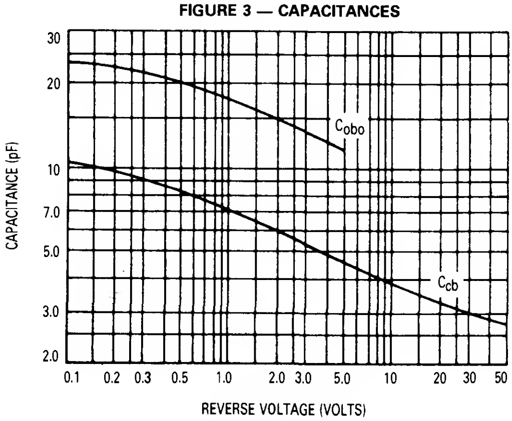


FIGURE 4 — CHARGE DATA

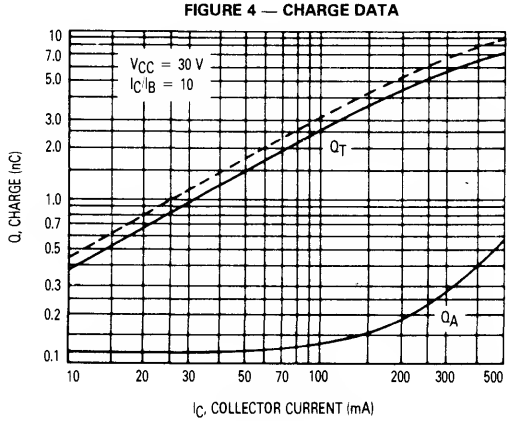


FIGURE 5 — TURN-ON TIME

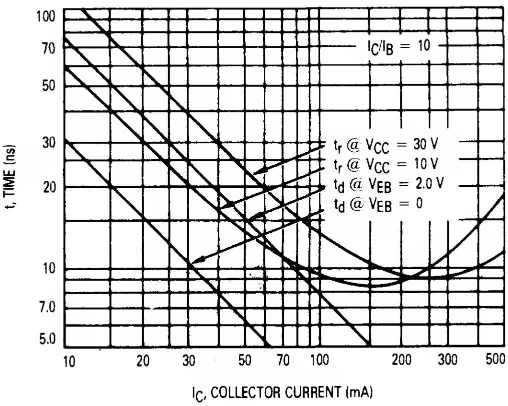


FIGURE 6 — RISE AND FALL TIMES

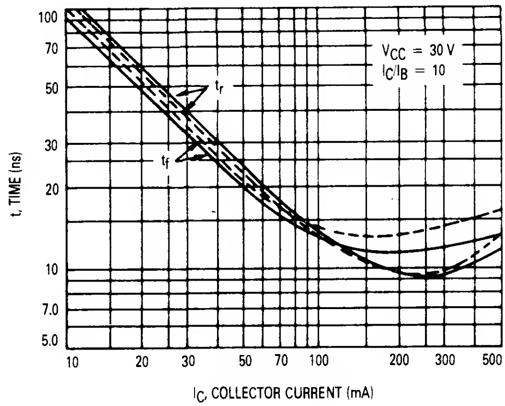


FIGURE 7 — STORAGE TIME

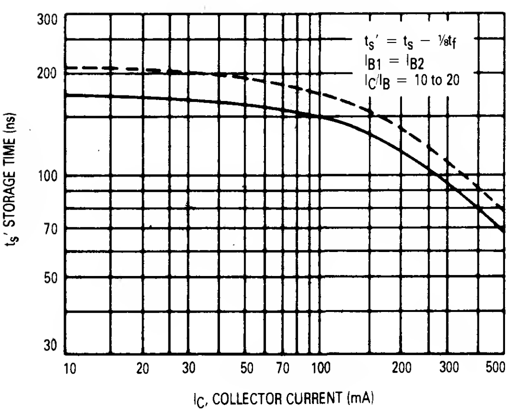
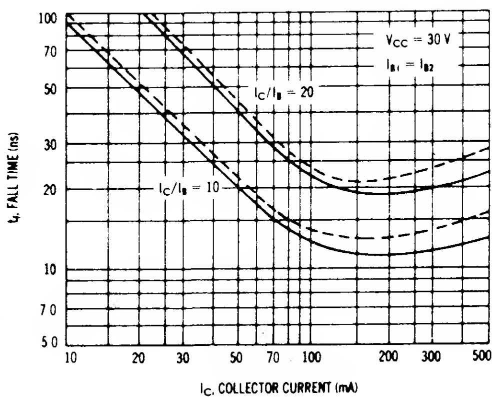


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

Bandwidth = 1.0 Hz

FIGURE 9 — FREQUENCY EFFECTS

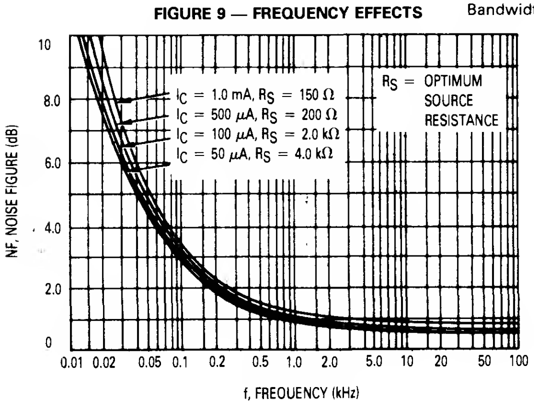
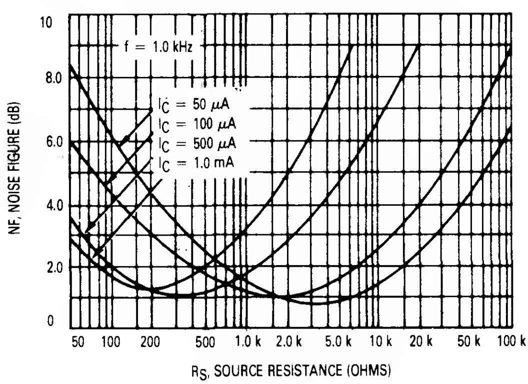


FIGURE 10 — SOURCE RESISTANCE EFFECTS



2

h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the 2N4400 and 2N4401 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 11 — CURRENT GAIN

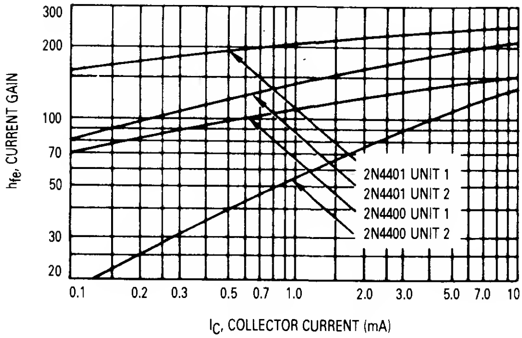


FIGURE 12 — UNPUT IMPEDANCE

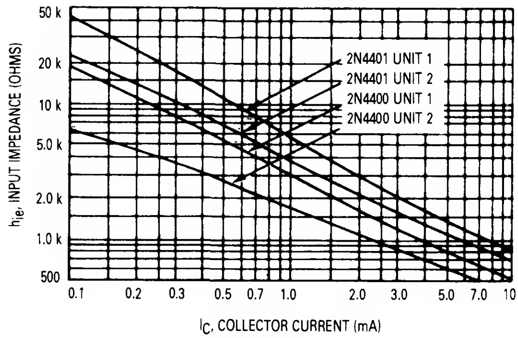


FIGURE 13 — VOLTAGE FEEDBACK RATIO

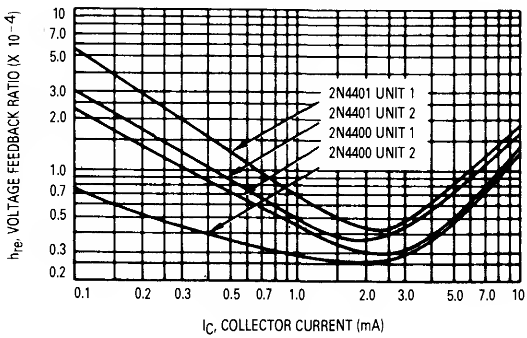
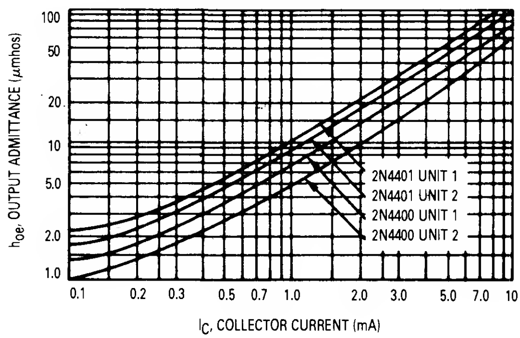


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

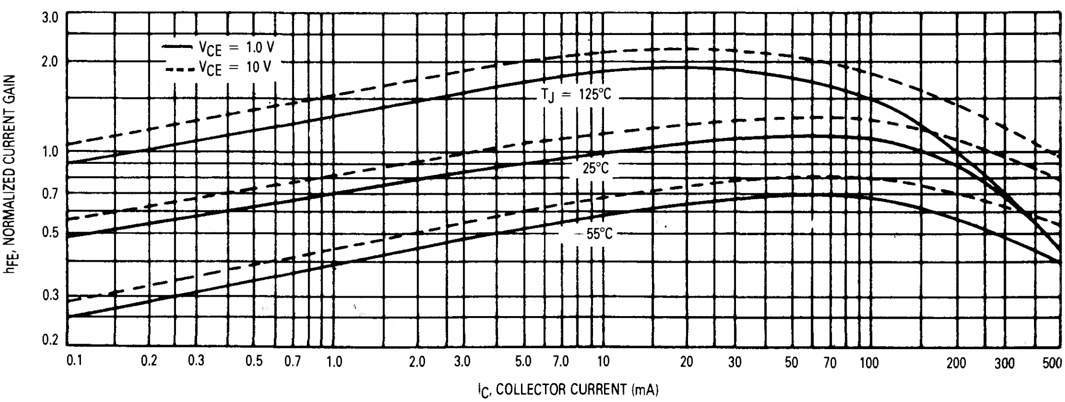


FIGURE 16 — COLLECTOR SATURATION REGION

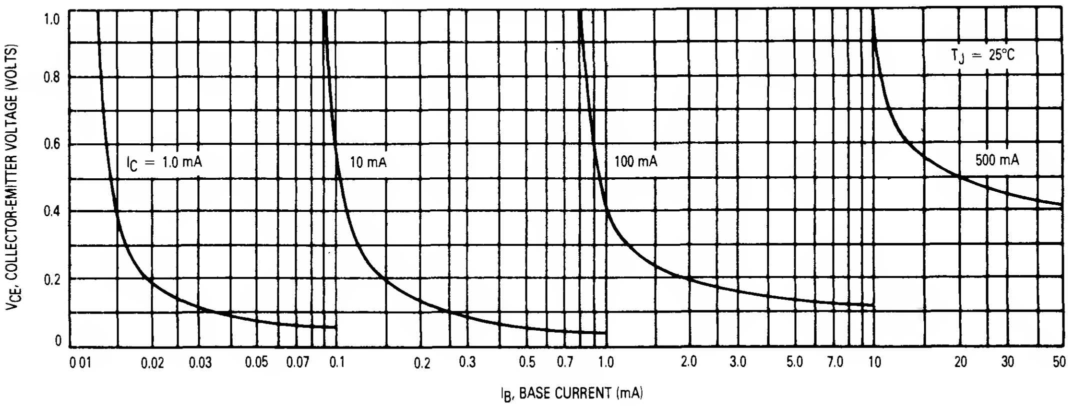


FIGURE 17 — "ON" VOLTAGES

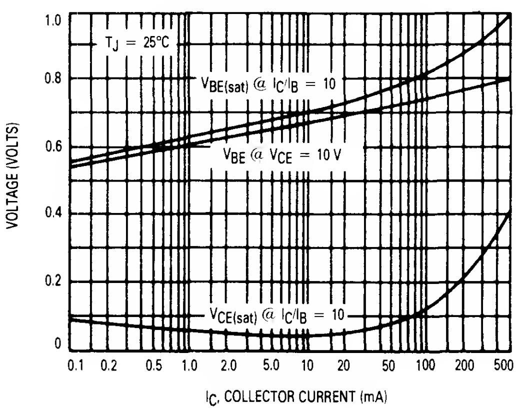
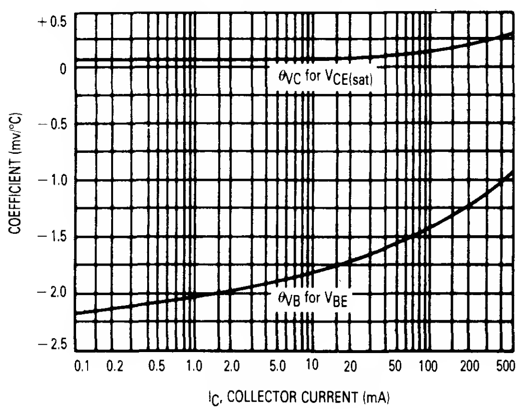


FIGURE 18 — TEMPERATURE COEFFICIENTS



2

2N4402
2N4403

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 35 Vdc, V_{BE} = 0.4 Vdc)		I_{BEV}	—	0.1	μAdc
Collector Cutoff Current (V_{CE} = 35 Vdc, V_{BE} = 0.4 Vdc)		I_{CEX}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N4403		30	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N4402 2N4403		30 60	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4402 2N4403		50 100	— —	
(I_C = 150 mAdc, V_{CE} = 2.0 Vdc)(1)	2N4402 2N4403		50 100	150 300	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)(1)	Both		20	—	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	 — —	 0.4 0.75	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	 0.75 —	 0.95 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	 2N4402 2N4403	f_T	 150 200	 — —	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{cb}	—	8.5	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{eb}	—	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 2N4402 2N4403	h_{ie}	 750 1.5k	 7.5k 15k	ohms

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4402	h_{fe}	30	250	—
	2N4403		60	500	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	100	μmhos

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, V_{BE} = 2.0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUIT

FIGURE 1 — TURN-ON TIME

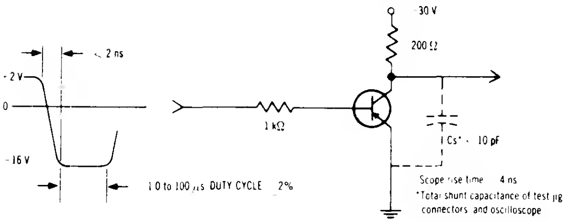
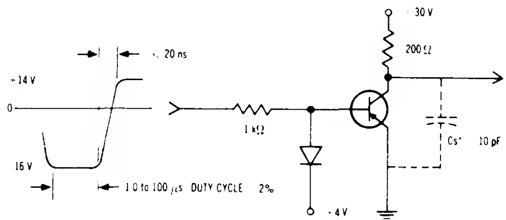


FIGURE 2 — TURN-OFF TIME



TRANSIENT CHARACTERISTICS

—— 25°C — — — 100°C

FIGURE 3 — CAPACITANCES

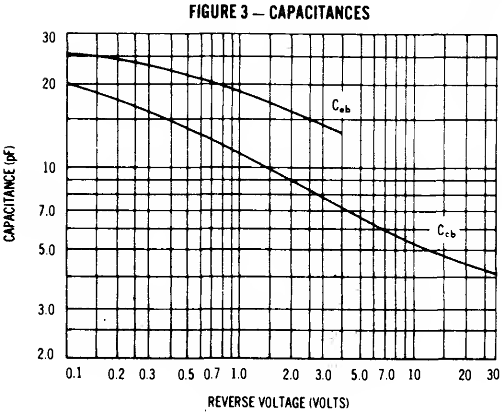


FIGURE 4 — CHARGE DATA

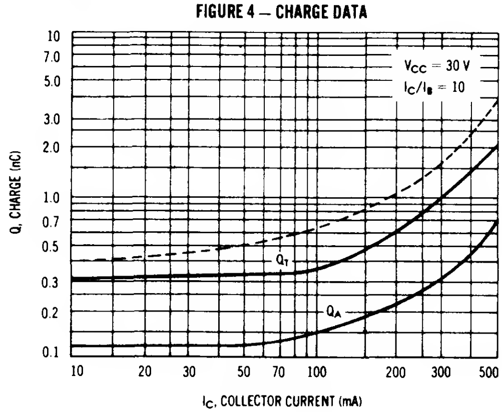


FIGURE 5 — TURN-ON TIME

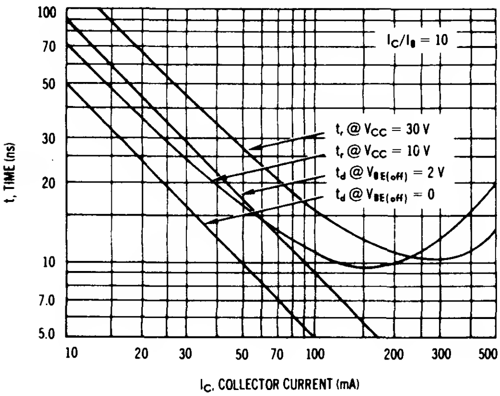


FIGURE 6 — RISE TIME

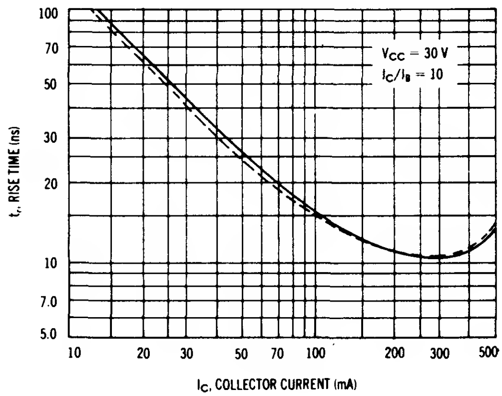
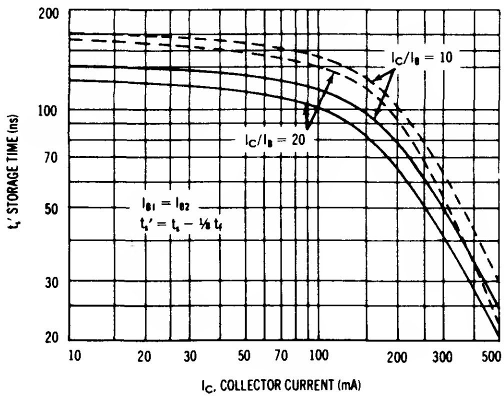


FIGURE 7 — STORAGE TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

Bandwidth = 1.0 Hz

FIGURE 8 — FREQUENCY EFFECTS

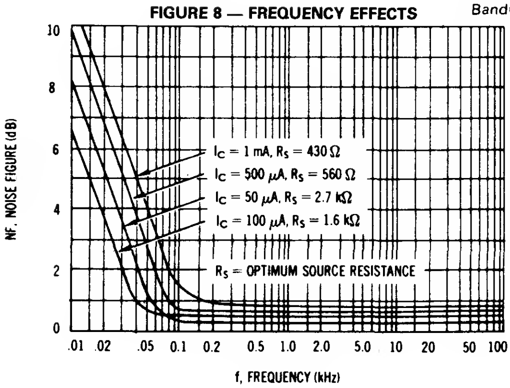
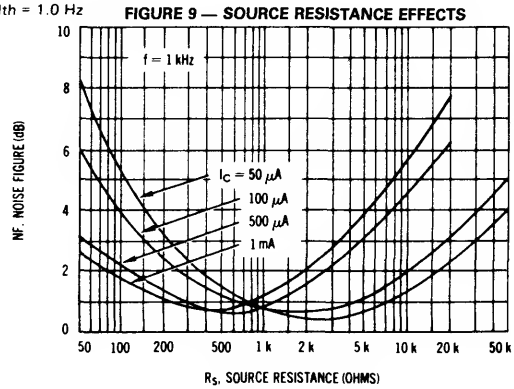


FIGURE 9 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the 2N4402 and 2N4403 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 10 — CURRENT GAIN

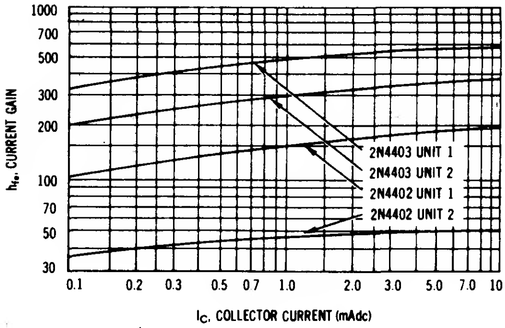


FIGURE 11 — INPUT IMPEDANCE

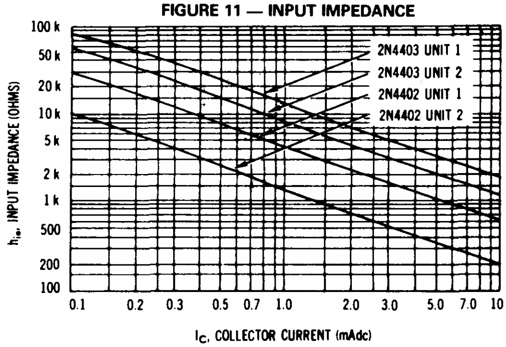


FIGURE 12 — VOLTAGE FEEDBACK RATIO

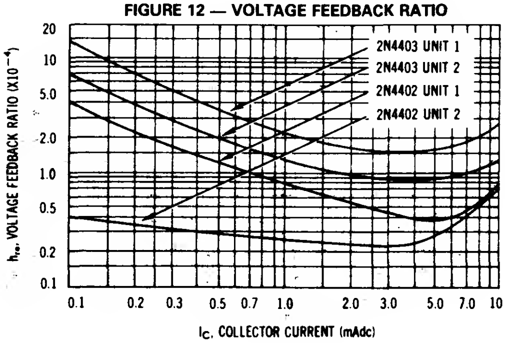
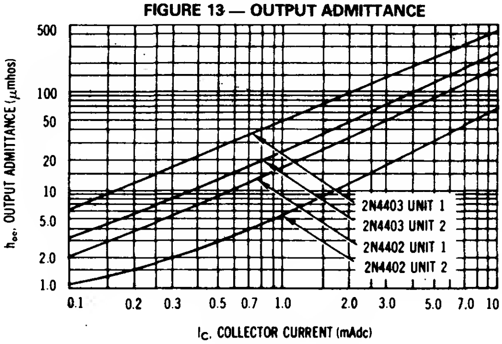
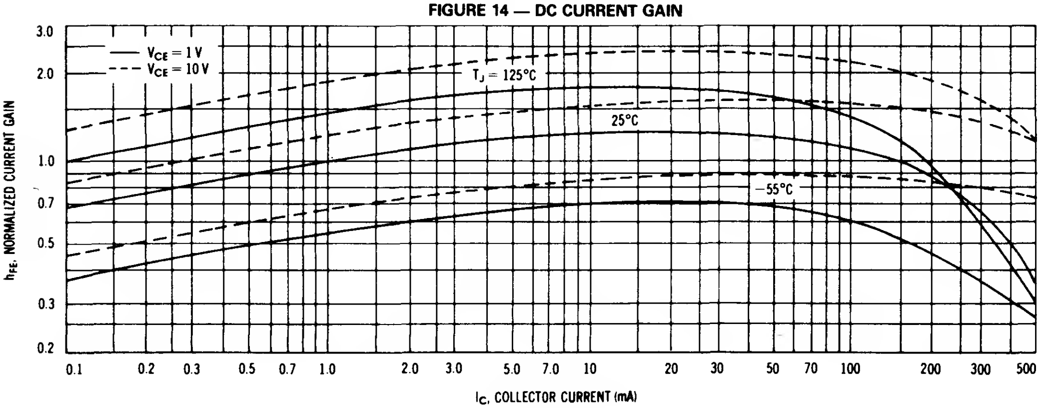


FIGURE 13 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 14 — DC CURRENT GAIN



2

FIGURE 15 — COLLECTOR SATURATION REGION

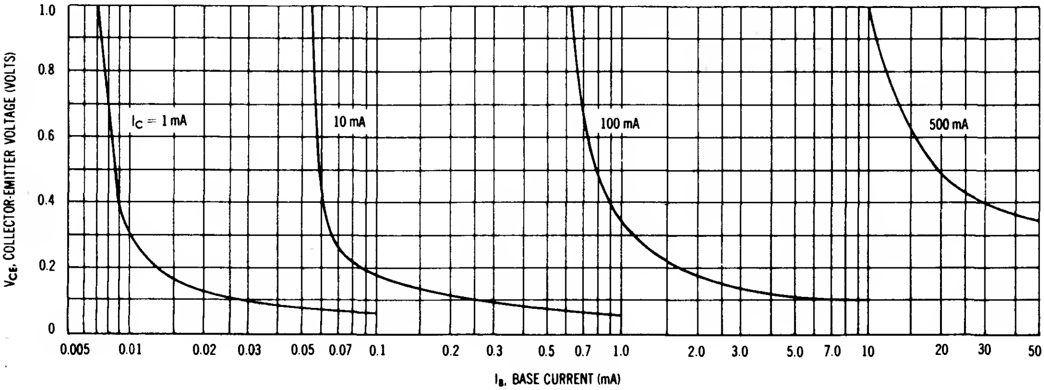


FIGURE 16 — "ON" VOLTAGES

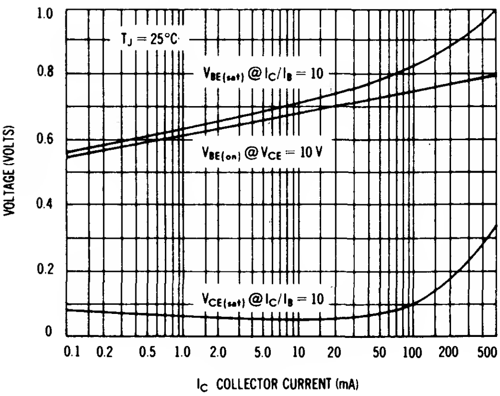
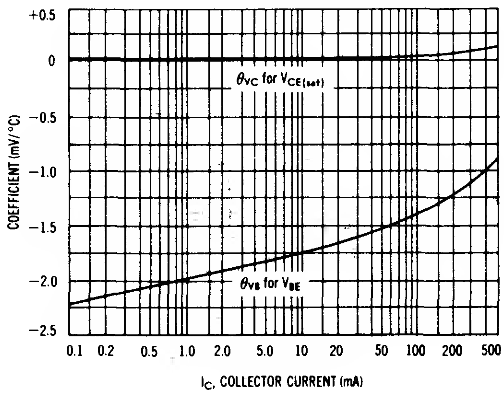


FIGURE 17 — TEMPERATURE COEFFICIENTS



2N4409
2N4410

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	2N4409	2N4410	Unit
Collector-Emitter Voltage	V_{CEO}	50	80	Vdc
Collector-Base Voltage	V_{CBO}	80	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	250		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

Refer to 2N5550 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 2N4409 2N4410	$V_{(BR)CEO}$	50 80	 — —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 500 μAdc, V_{BE} = 5.0 Vdc, R_{BE} = 8.2 kohms)	 2N4409 2N4410	$V_{(BR)CEX}$	 80 120	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N4409 2N4410	$V_{(BR)CBO}$	 80 120	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)	 2N4409 2N4409 2N4410 2N4410	I_{CBO}	 — — — —	 0.01 1.0 0.01 1.0	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	60 60	— 400	—
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{BE(sat)}$	—	0.8	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)		f_T	60	300	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz, emitter guarded)		C_{cb}	—	12	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz, collector guarded)		C_{eb}	—	50	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2

2N5086
2N5087

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	50	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 35 Vdc, I_E = 0)		I_{CBO}	 — —	 10 50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	 2N5086 2N5087	h_{FE}	 150 250	 500 800	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5086 2N5087		150 250	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(2)	2N5086 2N5087		150 250	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	40	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	 2N5086 2N5087	h_{fe}	 150 250	 600 900	—
Noise Figure (I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz)	 2N5086 2N5087	NF	 — —	 3.0 2.0	dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz)	2N5086 2N5087		— —	3.0 2.0	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N5088
2N5089

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	2N5088	2N5089	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	35	30	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

Refer to MPSA18 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	2N5088 2N5089	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N5088 2N5089	$V_{(BR)CBO}$	35 30	— —	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0)	2N5088 2N5089	I_{CBO}	— —	50 50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0) ($V_{EB(off)}$ = 4.5 Vdc, I_C = 0)		I_{EBO}	— —	50 100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	 2N5088 2N5089	h_{FE}	 300 400	 900 1200	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5088 2N5089		350 450	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(2)	2N5088 2N5089		300 400	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(2)		$V_{BE(on)}$	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	—	4.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	—	10	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	 2N5088 2N5089	h_{fe}	 350 450	 1400 1800	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 10 Hz to 15.7 kHz)	 2N5088 2N5089	NF	 — —	 3.0 2.0	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

2N5208

CASE 29-02, STYLE 2 TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

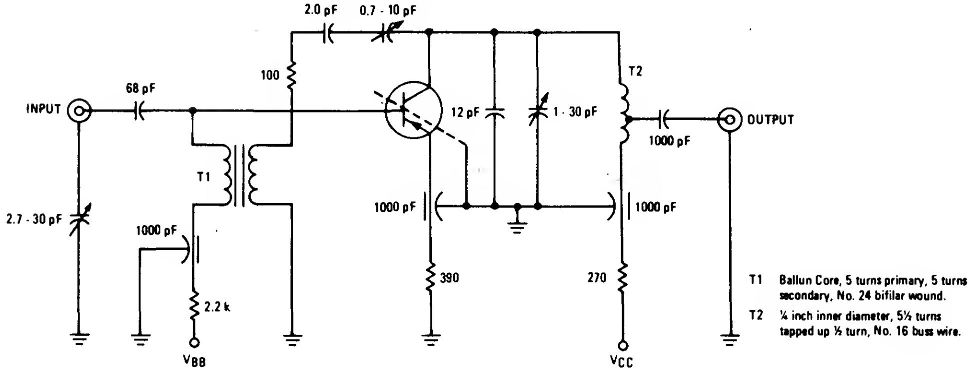
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	10	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	120	—
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	1200	MHz
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	4.0	pF
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	1.0	pF
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	—	10	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 75 ohms, f = 100 MHz, BW = 1.0 MHz)	NF	—	3.0	dB
FUNCTIONAL TEST				
Amplifier Power Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	G_{pe}	22	—	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

2

FIGURE 1 - 100 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



COMMON-EMITTER Y PARAMETERS (Polar Plots)

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 2 - INPUT ADMITTANCE

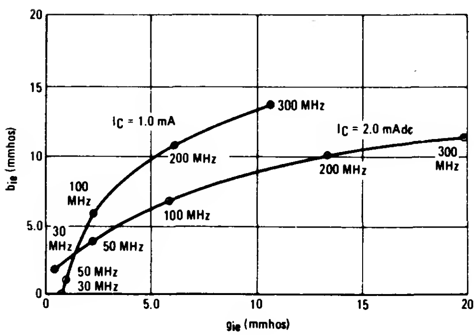


FIGURE 3 - OUTPUT ADMITTANCE

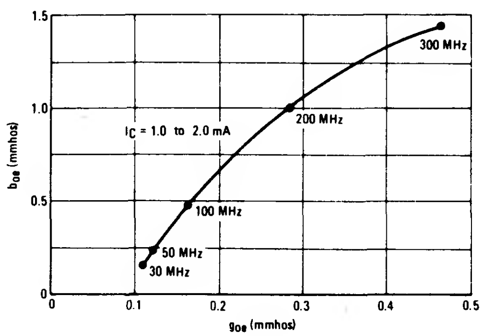


FIGURE 4 - FORWARD TRANSFER ADMITTANCE

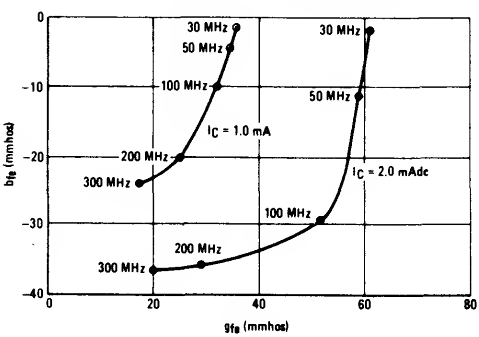
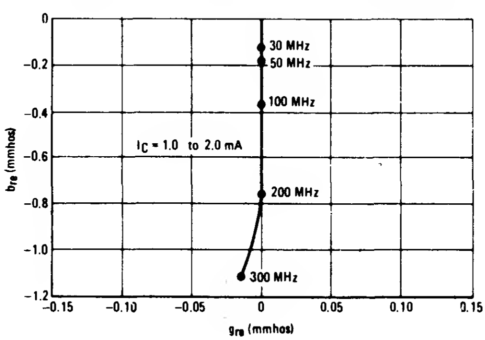


FIGURE 5 - REVERSE TRANSFER ADMITTANCE



STABILITY FACTOR CURVE

FIGURE 6 - POWER GAIN AND NOISE FIGURE

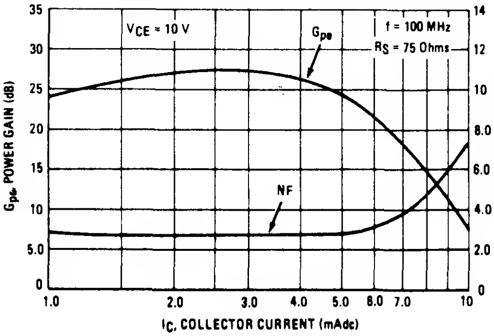
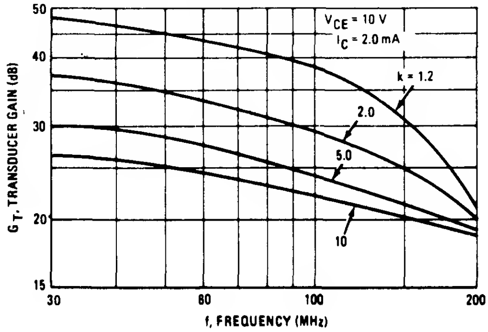


FIGURE 7 - MAXIMUM TRANSDUCER GAIN



COMMON-EMITTER Y PARAMETERS vs FREQUENCY

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 8 - INPUT ADMITTANCE

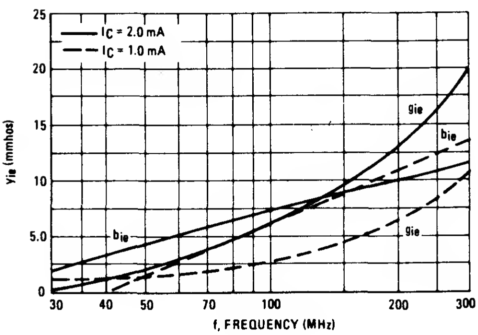


FIGURE 9 - OUTPUT ADMITTANCE

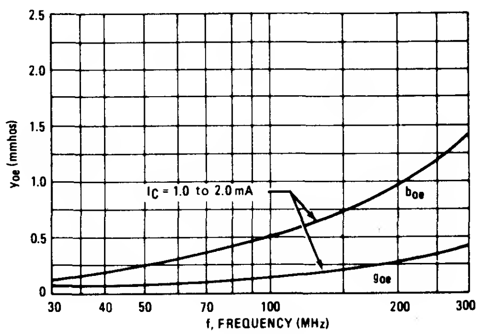


FIGURE 10 - FORWARD TRANSFER ADMITTANCE

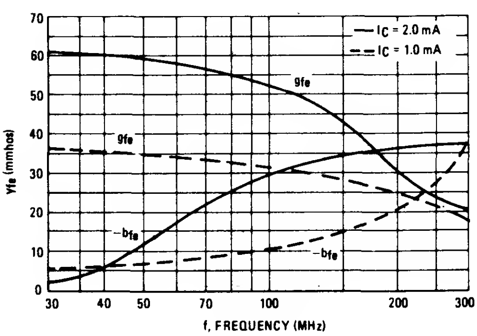
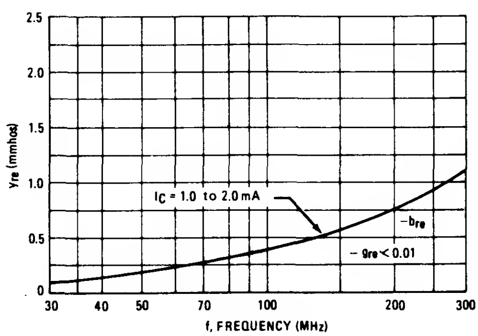


FIGURE 11 - REVERSE TRANSFER ADMITTANCE



STABILITY FACTOR CURVES

FIGURE 12 - OPTIMUM SOURCE ADMITTANCE

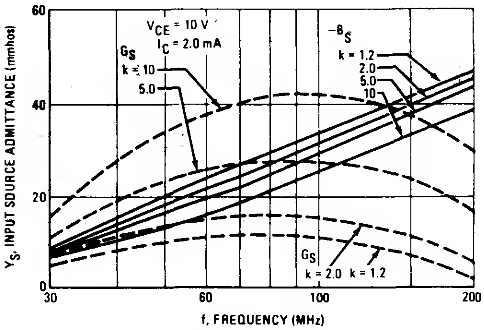
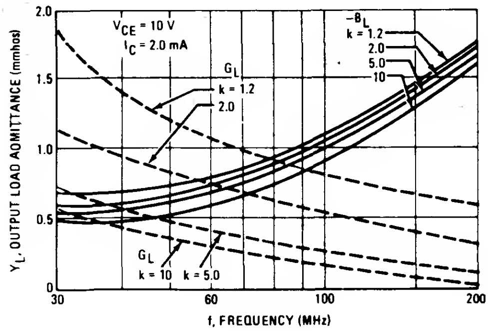


FIGURE 13 - OPTIMUM LOAD ADMITTANCE



When a potentially unstable device is operated without feedback, there is an infinite number of combinations of source and load admittance associated with any given circuit stability factor (k). Equations have been developed for determining the optimum source and load admittance for maximum gain. Figures 7, 12 and 13 provide a solution to the equations for the 2N5208.

NOISE FIGURE

FIGURE 14 - FREQUENCY EFFECTS

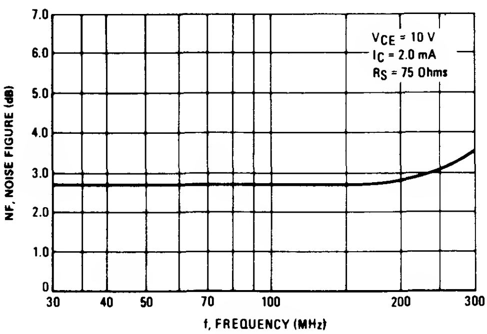


FIGURE 15 - SOURCE RESISTANCE EFFECTS

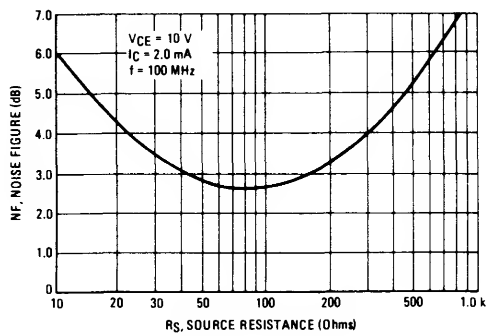


FIGURE 16 - CURRENT-GAIN—BANDWIDTH PRODUCT

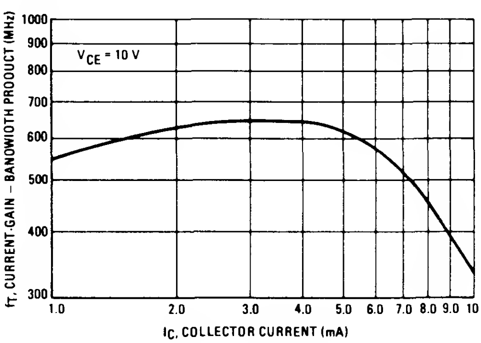


FIGURE 17 - CAPACITANCES

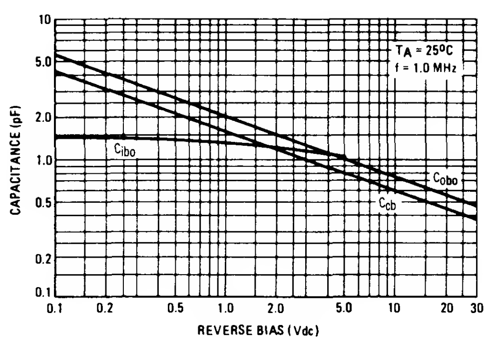
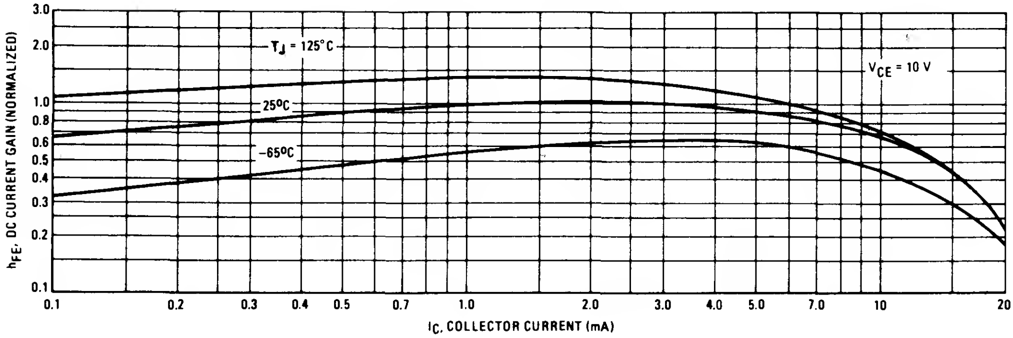


FIGURE 18 - DC CURRENT GAIN



2

2N5209
2N5210

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	50	—	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N5209 2N5210	h_{FE}	100 200	300 600	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5209 2N5210		150 250	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(2)	2N5209 2N5210		150 250	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	30	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5209 2N5210	h_{fe}	150 250	600 900	—
Noise Figure (I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 22 k ohms, f = 10 Hz to 15.7 kHz)	2N5209 2N5210	NF	— —	3.0 2.0	dB
(I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	2N5209 2N5210		— —	4.0 3.0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

2

2N5400
2N5401

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5400	2N5401	Unit
Collector-Emitter Voltage	V_{CEO}	120	150	Vdc
Collector-Base Voltage	V_{CBO}	130	160	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 2N5400 2N5401	$V_{(BR)CEO}$	 120 150	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N5400 2N5401	$V_{(BR)CBO}$	 130 160	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	 2N5400 2N5401 2N5400 2N5401	I_{CBO}	 — — — —	 100 50 100 50	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	 2N5400 2N5401 2N5400 2N5401 2N5400 2N5401	h_{FE}	 30 50 40 60 40 50	 — — 180 240 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	 — —	 0.20 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	 — —	 1.0 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 Mhz)	 2N5400 2N5401	f_T	 100 100	 400 300	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5400 2N5401	h_{fe}	30 40	200 200	—
Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohm, f = 10 Hz to 15.7 kHz)		NF	—	8.0	dB

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — DC CURRENT GAIN

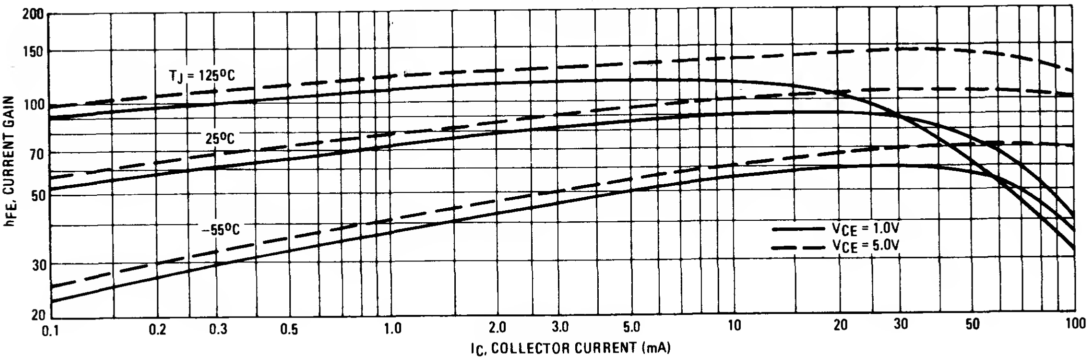


FIGURE 2 — COLLECTOR SATURATION REGION

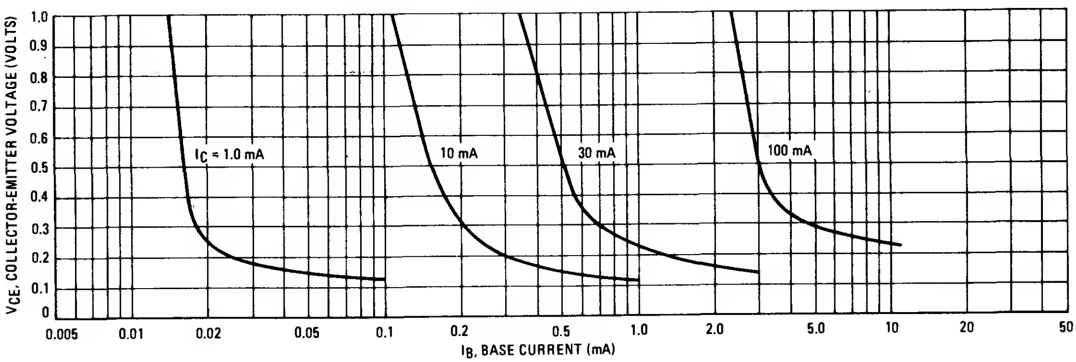


FIGURE 3 — COLLECTOR CUT-OFF REGION

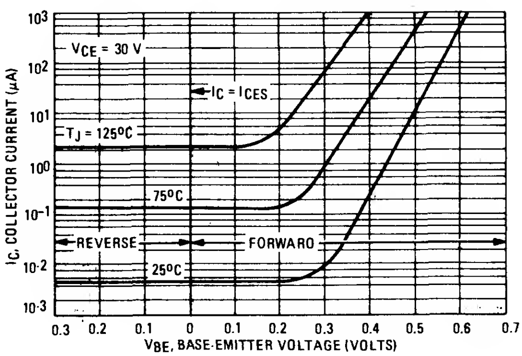


FIGURE 4 – "ON" VOLTAGES

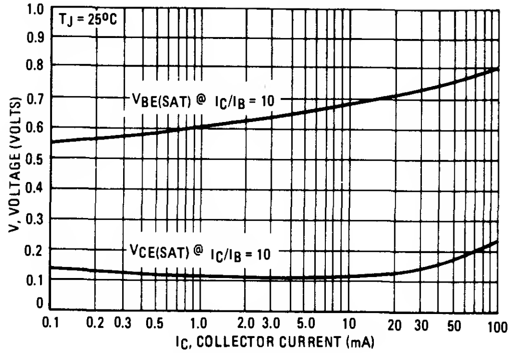


FIGURE 5 – TEMPERATURE COEFFICIENTS

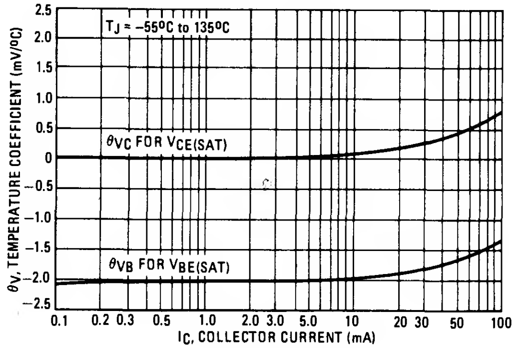


FIGURE 6 – SWITCHING TIME TEST CIRCUIT

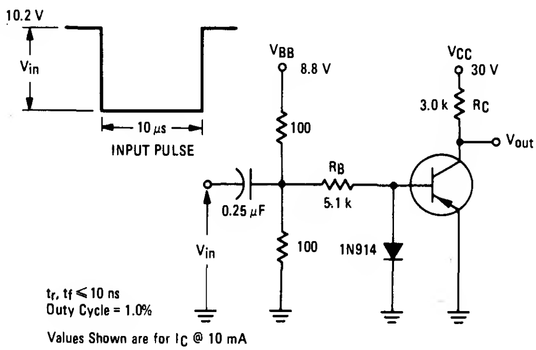


FIGURE 7 – CAPACITANCES

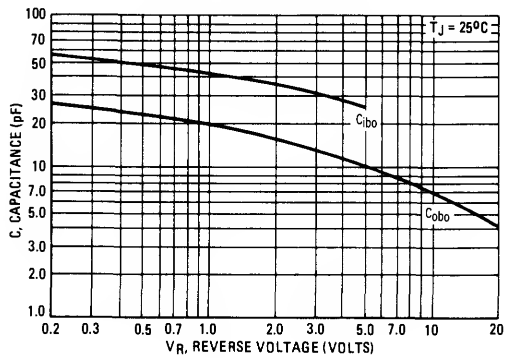


FIGURE 8 – TURN-ON TIME

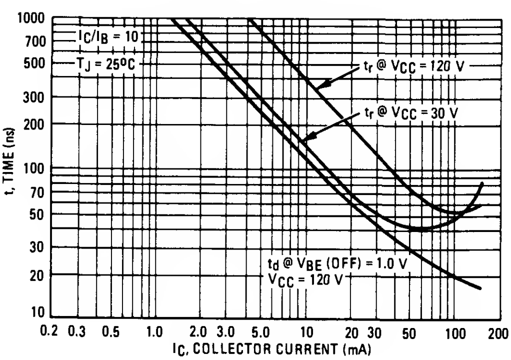
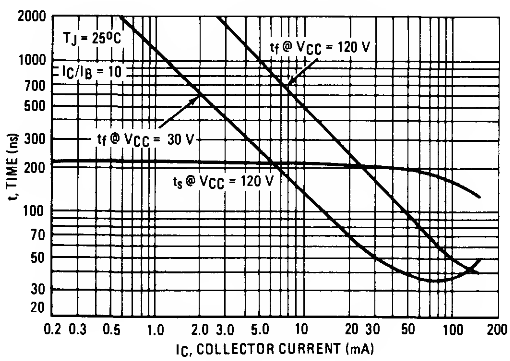


FIGURE 9 – TURN-OFF TIME



2

2N5550
2N5551

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5550	2N5551	Unit
Collector-Emitter Voltage	V_{CEO}	140	160	Vdc
Collector-Base Voltage	V_{CBO}	160	180	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	 2N5550 2N5551	$V_{(BR)CEO}$	 140 160	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N5550 2N5551	$V_{(BR)CBO}$	 160 180	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	 2N5550 2N5551 2N5550 2N5551	I_{CBO}	 — — — —	 100 50 100 50	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	 2N5550 2N5551 2N5550 2N5551 2N5550 2N5551	h_{FE}	 60 80 60 80 20 30	 — — 250 250 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types 2N5550 2N5551	$V_{CE(sat)}$	 — — —	 0.15 0.25 0.20	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types 2N5550 2N5551	$V_{BE(sat)}$	 — — —	 1.0 1.2 1.0	Vdc

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	100	300	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N5550	C_{ibo}	—	30	pF
	2N5551		—	20	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	50	200	—
Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohm, f = 10 Hz to 15.7 kHz)	2N5550	NF	—	10	dB
	2N5551		—	8.0	

(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — DC CURRENT GAIN

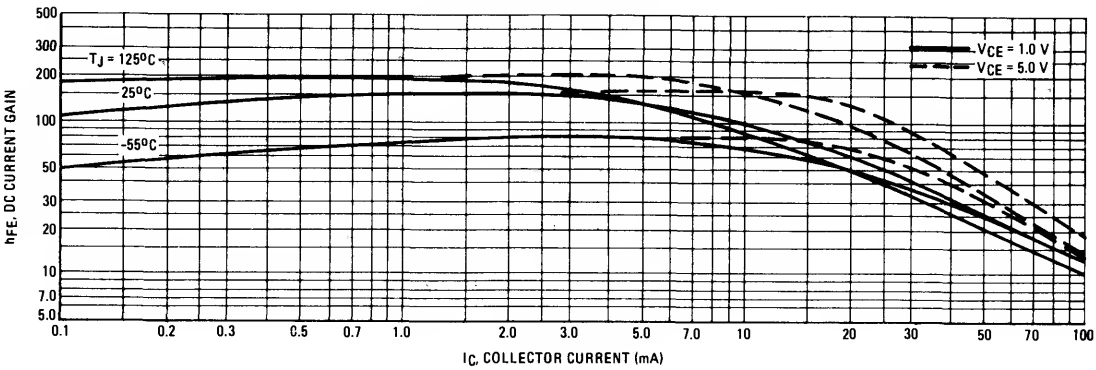


FIGURE 2 — COLLECTOR SATURATION REGION

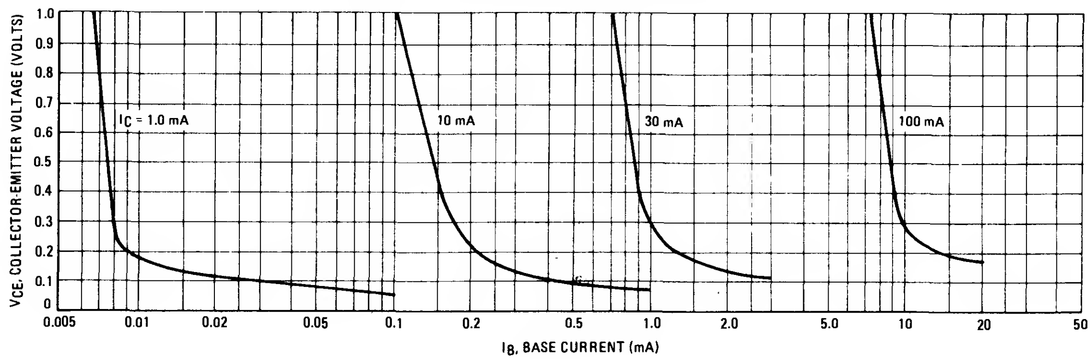


FIGURE 3 – COLLECTOR CUT-OFF REGION

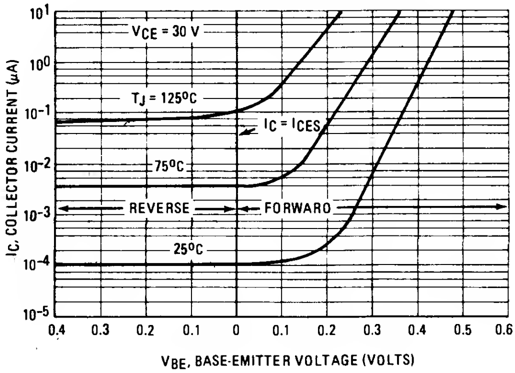


FIGURE 4 – "ON" VOLTAGES

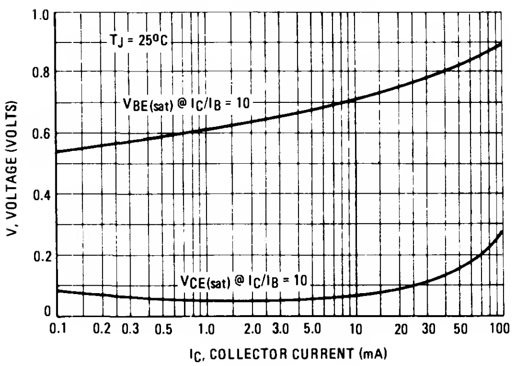


FIGURE 5 – TEMPERATURE COEFFICIENTS

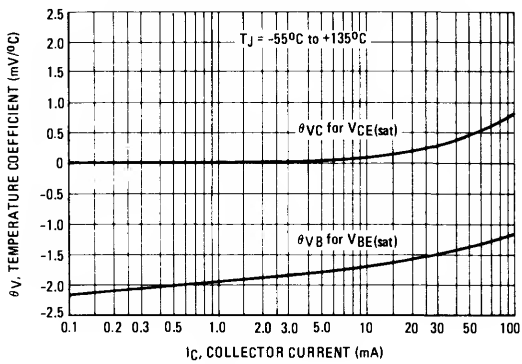


FIGURE 6 – SWITCHING TIME TEST CIRCUIT

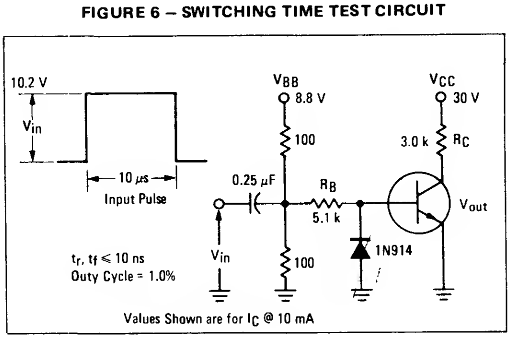


FIGURE 7 – CAPACITANCES

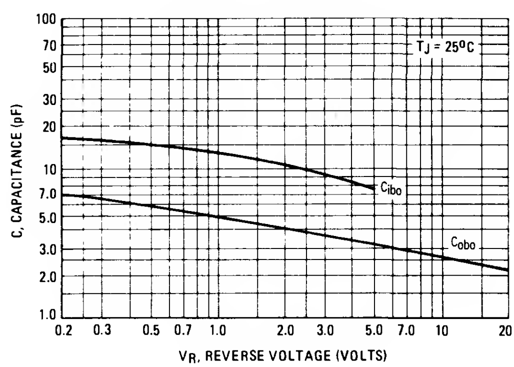


FIGURE 8 — TURN-ON TIME

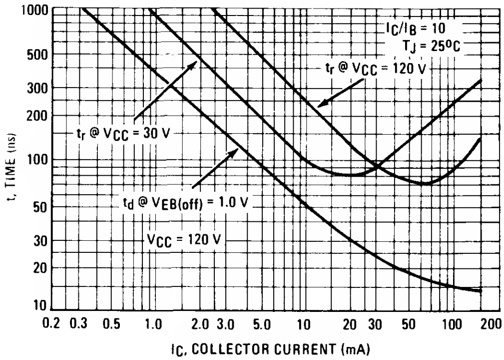
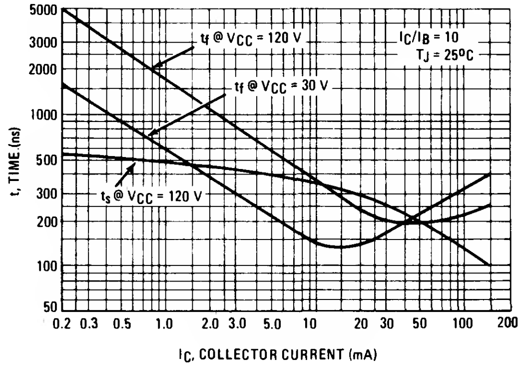


FIGURE 9 — TURN-OFF TIME



2N5771

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.625	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C
Lead Temperature	T_L	260	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 3.0$ mA)(1)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μA)	$V_{(BR)CES}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μA)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μA)	$V_{(BR)EBO}$	4.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 8.0$ Vdc)	I_{CBO}	—	10	nA
Collector Cutoff Current ($V_{CE} = 8.0$ Vdc) ($V_{CE} = 8.0$ Vdc, $T_A = 125°C$)	I_{CES}	— —	10 5.0	nA μA
Emitter Cutoff Current ($V_{BE} = 4.5$ Vdc)	I_{EBO}	—	1.0	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mA, $V_{CE} = 0.5$ Vdc)(1) ($I_C = 10$ mA, $V_{CE} = 0.3$ Vdc)(1) ($I_C = 50$ mA, $V_{CE} = 1.0$ Vdc)(1) ($I_C = 10$ mA, $V_{CE} = 0.3$ Vdc, $T_A = -55°C$)	h_{FE}	35 50 40 20	— 120 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 1.0$ mA, $I_B = 0.1$ mA) ($I_C = 10$ mA, $I_B = 1.0$ mA) ($I_C = 50$ mA, $I_B = 5.0$ mA)	$V_{CE(sat)}$	— — —	0.15 0.18 0.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 1.0$ mA, $I_B = 0.1$ mA) ($I_C = 10$ mA, $I_B = 1.0$ mA) ($I_C = 50$ mA, $I_B = 5.0$ mA)	$V_{BE(sat)}$	— 0.75 —	0.8 0.95 1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, f = 140 kHz)	C_{cb}	—	3.0	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, f = 140 kHz)	C_{eb}	—	3.5	pF
Small-Signal Current Gain ($I_C = 10$ mA, $V_{CE} = 10$ Vdc, f = 100 MHz)	h_{fe}	8.5	—	—
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = 10$ mA, $I_{B1} \approx I_{B2} \approx 10$ mA)	t_s	—	20	ns
Turn-On Time ($I_C = 10$ mA, $I_B = 1.0$ mA)	t_{on}	—	15	ns
Turn-Off Time ($I_C = 10$ mA, $I_{B1} = I_{B2} = 1.0$ mA)	t_{off}	—	20	ns

(1) Pulse Conditions: Pulse Length = 300 μs, Duty Cycle = 1.0%.

2

2N6426
2N6427

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

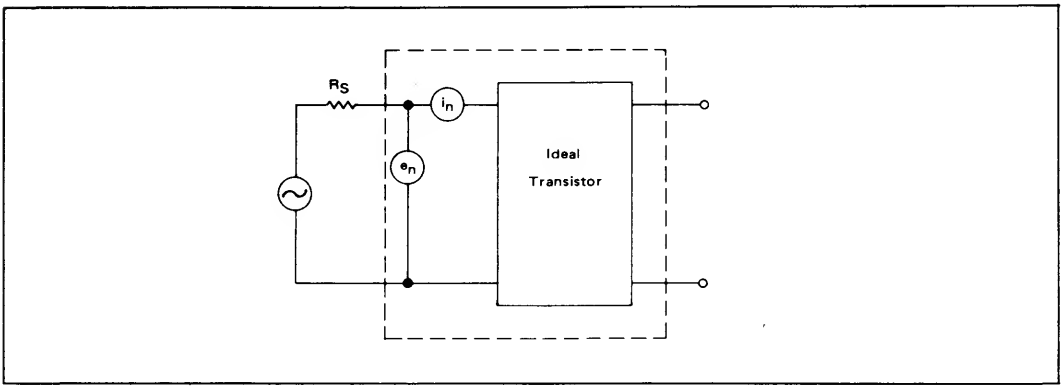
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)		I_{CEO}	—	—	1.0	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N6426 2N6427		20,000 10,000	— —	200,000 100,000	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	2N6426 2N6427		30,000 20,000	— —	300,000 200,000	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N6426 2N6427		20,000 14,000	— —	200,000 140,000	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 0.5 mAdc) (I_C = 500 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	 — —	 0.71 0.9	 1.2 1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 0.5 mAdc)		$V_{BE(sat)}$	—	1.52	2.0	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	1.24	1.75	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	5.4	7.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	10	15	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Impedance (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6426	h_{ie}	100	—	2000	k Ω
	2N6427		50	—	1000	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6426	h_{fe}	20,000	—	—	—
	2N6427		10,000	—	—	
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	2N6426	$\|h_{fe}\|$	1.5	2.4	—	—
	2N6427		1.3	2.4	—	
Output Admittance (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{oe}	—	—	1000	μmhos
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 kΩ, f = 10 kHz to 15.7 kHz)		NF	—	3.0	10	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 2 – NOISE VOLTAGE

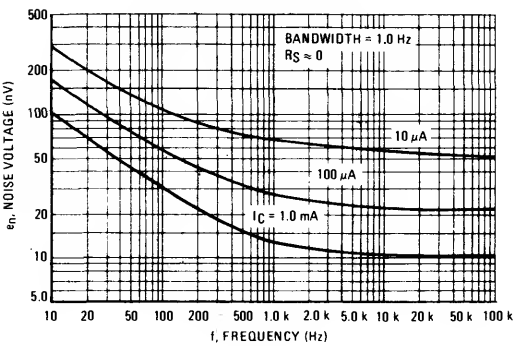


FIGURE 3 – NOISE CURRENT

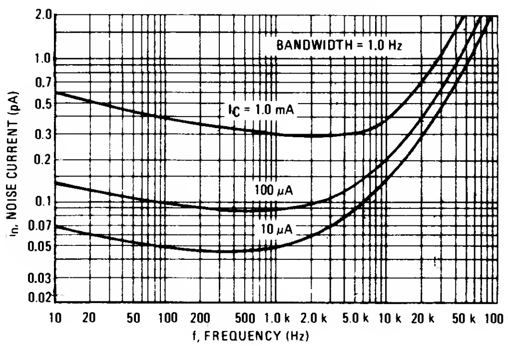


FIGURE 4 – TOTAL WIDEBAND NOISE VOLTAGE

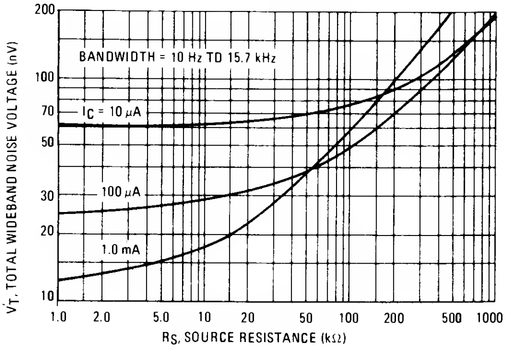
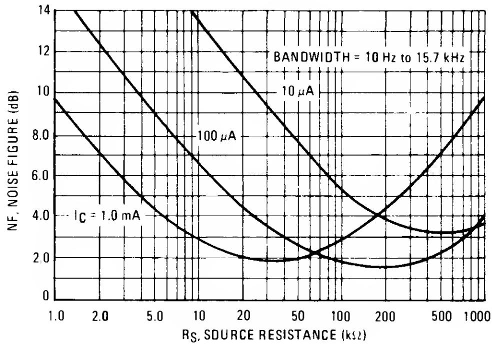


FIGURE 5 – WIDEBAND NOISE FIGURE



SMALL-SIGNAL CHARACTERISTICS

FIGURE 6 – CAPACITANCE

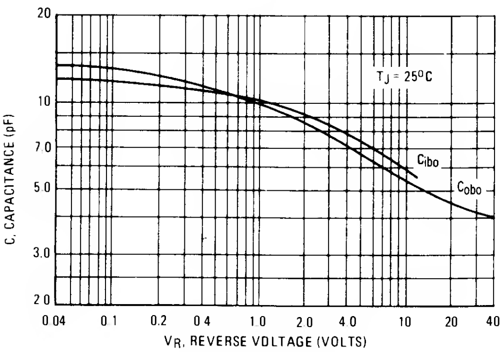


FIGURE 7 – HIGH FREQUENCY CURRENT GAIN

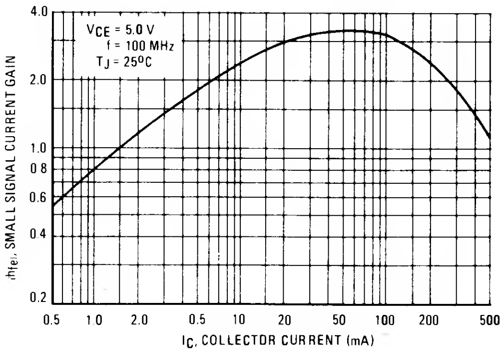


FIGURE 8 – DC CURRENT GAIN

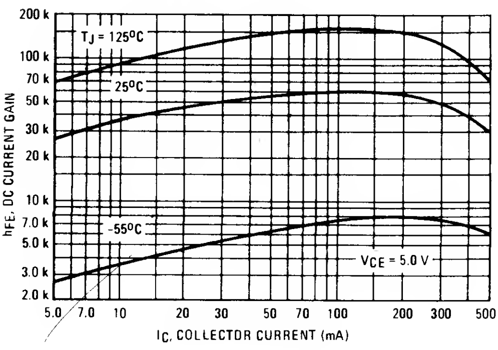


FIGURE 9 – COLLECTOR SATURATION REGION

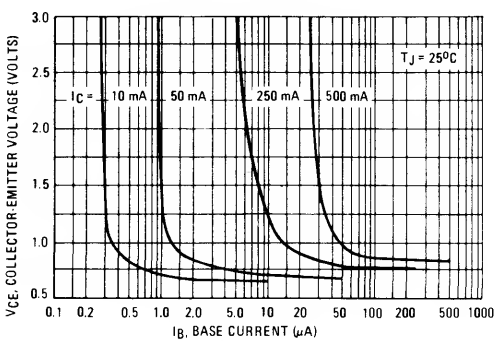


FIGURE 10 – "ON" VOLTAGES

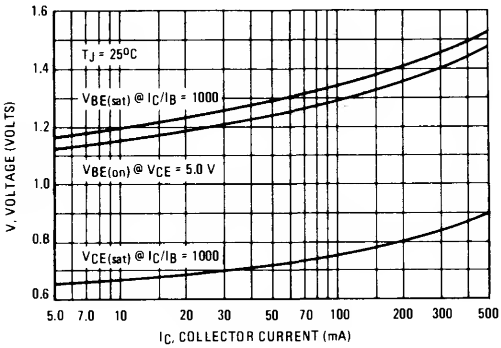


FIGURE 11 – TEMPERATURE COEFFICIENTS

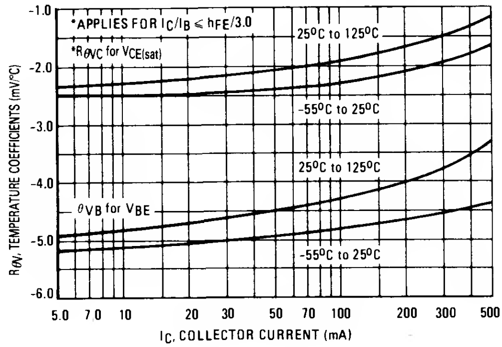


FIGURE 12 – THERMAL RESPONSE

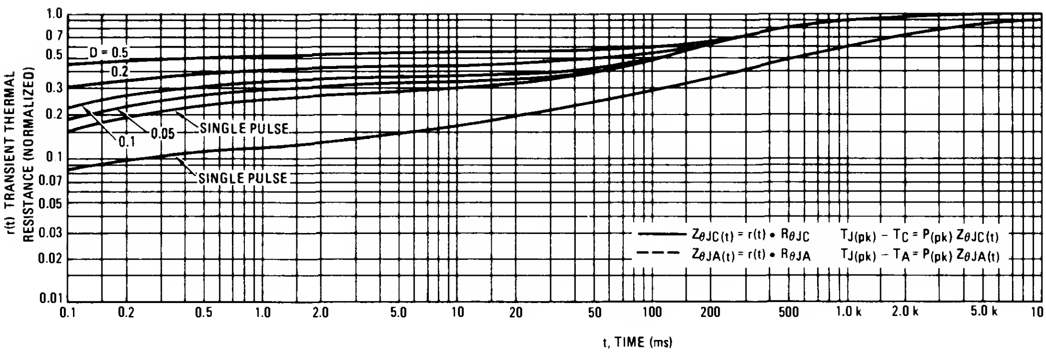
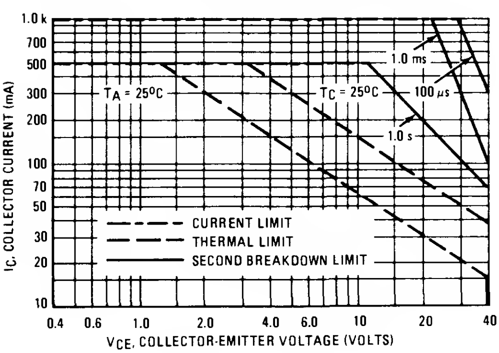
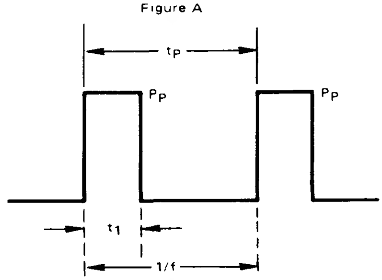


FIGURE 13 – ACTIVE REGION SAFE OPERATING AREA



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

Figure A



Duty Cycle = $t_1 f = \frac{t_1}{t_P}$

Peak Pulse Power = P_P

NPN 2N6515 thru 2N6517 PNP 2N6518 thru 2N6520

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	2N6515 2N6518	2N6516 2N6519	2N6517 2N5520	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	350	Vdc
Collector-Base Voltage	V_{CBO}	250	300	350	Vdc
Emitter-Base Voltage 2N6515, 2N6516, 2N6517	V_{EBO}		6.0		Vdc
2N6518, 2N6519, 2N6520			5.0		
Base Current	I_B		250		mAdc
Collector Current — Continuous	I_C		500		mAdc
Total Device Dissipation @ T_A = 25°C	P_D		0.625		Watt
Derate above 25°C			5.0		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C
Lead Temperature ≥ 1/16″ from case for 10 seconds	T_L		260		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CEO}$			Vdc
(I_C = 1.0 mAdc, I_B = 0)	2N6515, 2N6518		250	—	
	2N6516, 2N6519		300	—	
	2N6517, 2N6520		350	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 100 μAdc, I_E = 0)	2N6515, 2N6518		250	—	
	2N6516, 2N6519		300	—	
	2N6517, 2N6520		350	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$			Vdc
(I_E = 10 μAdc, I_C = 0)	2N6515, 2N6516, 2N6517		6.0	—	
	2N6518, 2N6519, 2N6520		5.0	—	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 150 Vdc, I_E = 0)	2N6515, 2N6518		—	50	
(V_{CB} = 200 Vdc, I_E = 0)	2N6516, 2N6519		—	50	
(V_{CB} = 250 Vdc, I_E = 0)	2N6517, 2N6520		—	50	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 5.0 Vdc, I_C = 0)	2N6515, 2N6516, 2N6517		—	50	
(V_{EB} = 4.0 Vdc, I_C = 0)	2N6518, 2N6519, 2N6520		—	50	
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N6515, 2N6518		35	—	
	2N6516, 2N6519		30	—	
	2N6517, 2N6520		20	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N6515, 2N6518		50	—	
	2N6516, 2N6519		45	—	
	2N6517, 2N6520		30	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)	2N6515, 2N6518		50	300	
	2N6516, 2N6519		45	270	
	2N6517, 2N6520		30	200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	2N6515, 2N6518		45	220	
	2N6516, 2N6519		40	200	
	2N6517, 2N6520		20	100	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	2N6515, 2N6518		25	—	
	2N6516, 2N6519		20	—	
	2N6517, 2N6520		15	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

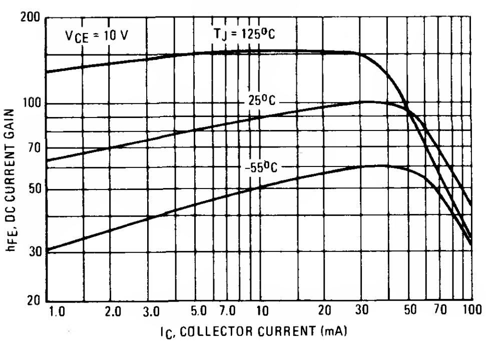
Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.30	
(I_C = 20 mAdc, I_B = 2.0 mAdc)		—	0.35	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		—	0.50	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	1.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.75	
(I_C = 20 mAdc, I_B = 2.0 mAdc)		—	0.85	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		—	0.90	
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance	C_{eb}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz) 2N6515 thru 2N6517		—	80	
2N6518 thru 2N6520		—	100	
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 50 mAdc, I_{B1} = 10 mAdc)	t_{on}	—	200	ns
Turn-Off Time (V_{CC} = 100 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_{off}	—	3.5	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

NPN

2N6515, 2N6516



PNP

2N6518, 2N6519

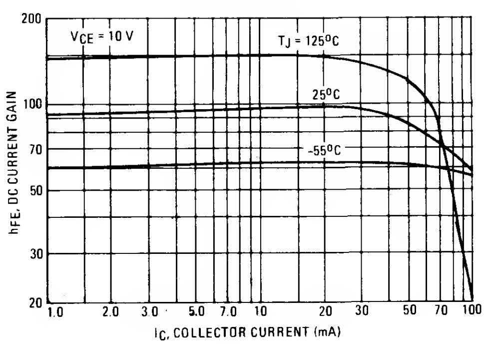


FIGURE 2 – DC CURRENT GAIN

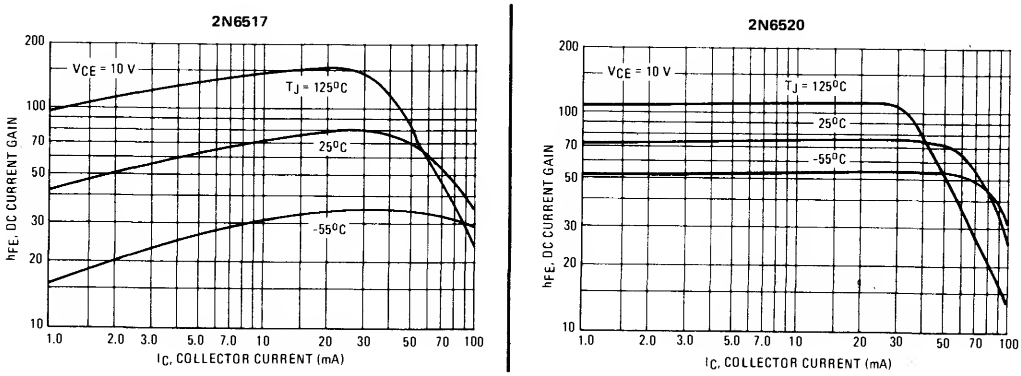
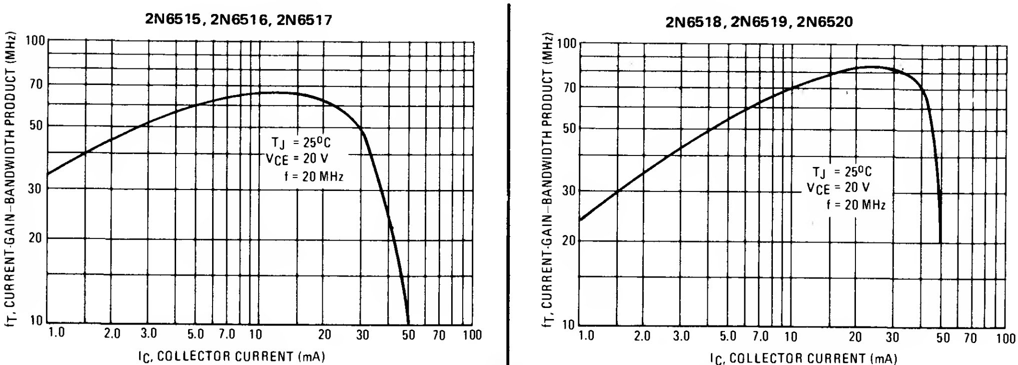


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT



NPN

PNP

FIGURE 4 – "ON" VOLTAGES

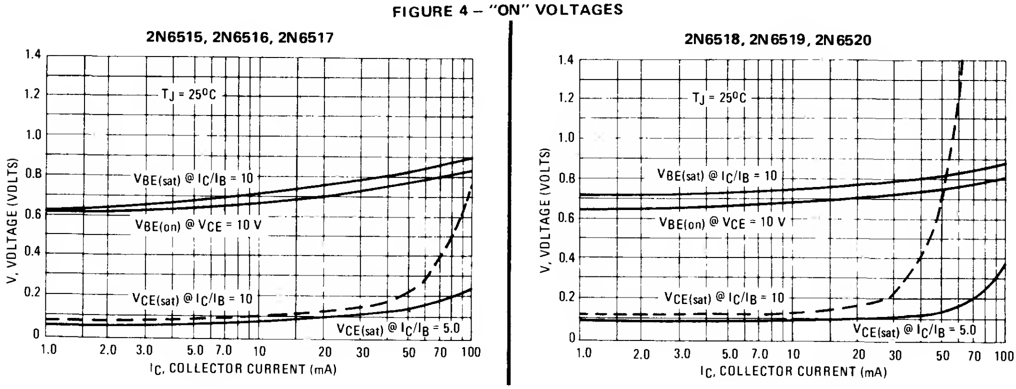


FIGURE 5 — TEMPERATURE COEFFICIENTS

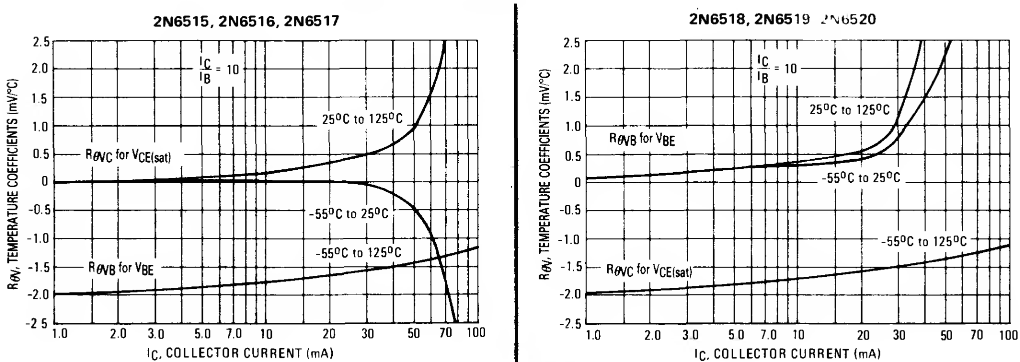


FIGURE 6 — CAPACITANCE

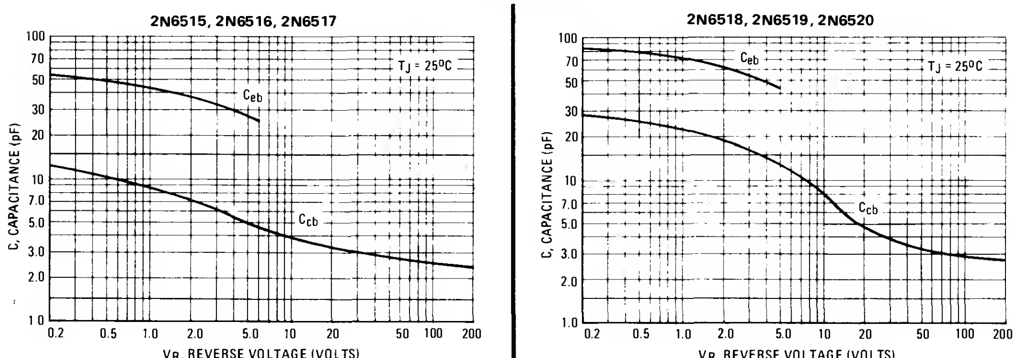


FIGURE 7 — TURN-ON TIME

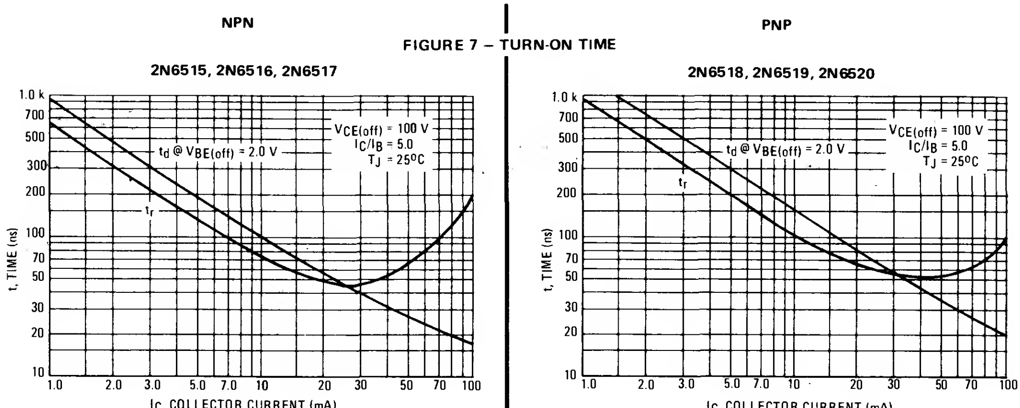


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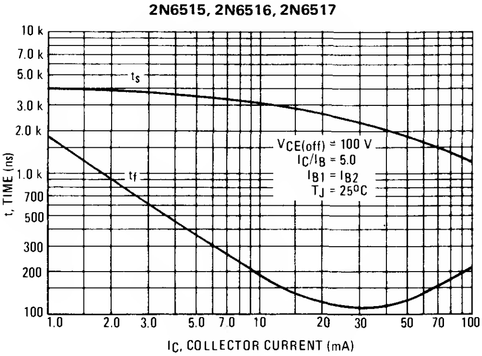
FIGURE 8 – TURN-OFF TIME



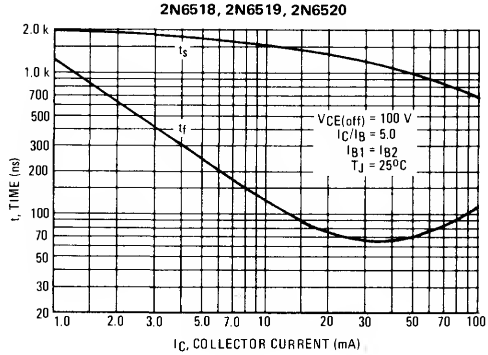
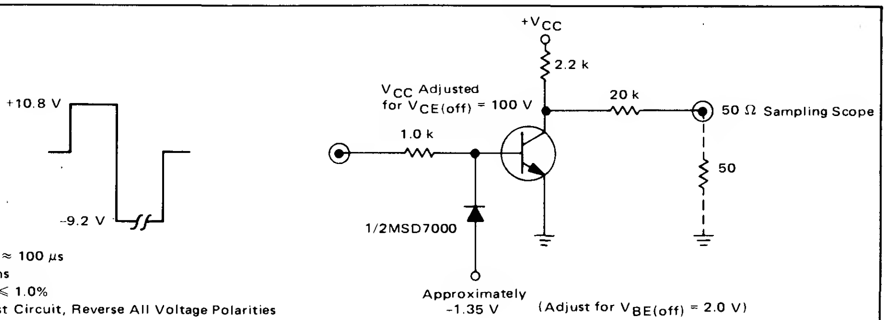
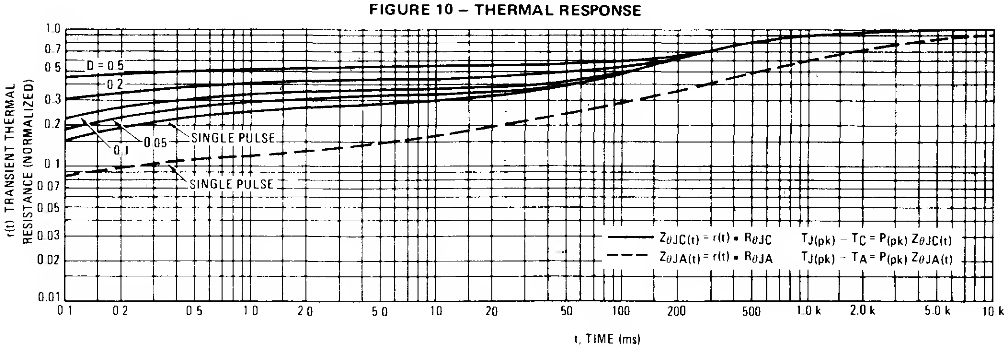


FIGURE 9 – SWITCHING TIME TEST CIRCUIT



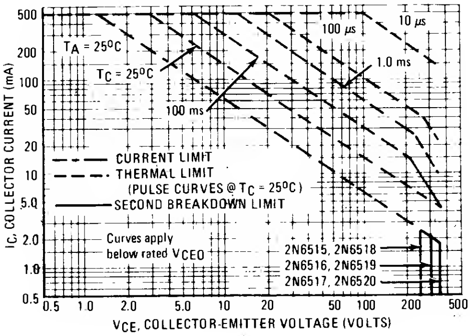
Pulse Width ≈ 100 μs
t_r, t_f ≤ 5.0 ns
Duty Cycle ≤ 1.0%
For PNP Test Circuit, Reverse All Voltage Polarities

FIGURE 10 – THERMAL RESPONSE



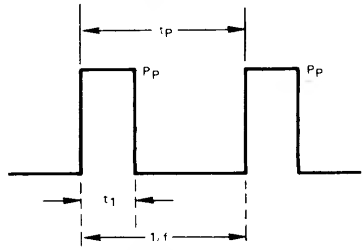
NPN 2N6515 thru 2N6517, PNP 2N6518 thru 2N6520

FIGURE 11 – ACTIVE REGION SAFE OPERATING AREA



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

Figure A



Duty Cycle = $t_1 f = \frac{t_1}{t_P}$

Peak Pulse Power = P_P

2

BC174
BC171
BC172

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

Refer to BC546 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 174	BC 171	BC 172	Unit
Collector-Emitter Voltage	V_{CEO}	65	45	25	Vdc
Collector-Base Voltage	V_{CBO}	80	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current – Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.B			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 B.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1 mA, I_B = 0)	BC174 BC171 BC172	$V_{(BR)CEO}$	65 45 25			V
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	BC171 BC172 BC174	$V_{(BR)EBO}$	6 6 6			V
Collector Cutoff Current (V_{CE} = 70 V, V_{BE} = 0) (V_{CE} = 50 V, V_{BE} = 0) (V_{CE} = 35 V, V_{BE} = 0)	BC174 BC171 BC172	I_{CES}		0.20 0.20 0.20	15 15 15	nA
(V_{CE} = 30 V, T_A = 125°C)	BC174 BC171 BC172				4 4 4	μA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5 V)	BC171A/2A/4A BC171B/2B/4B BC172C	h_{FE}		90 150 270		
(I_C = 2 mA, V_{CE} = 5 V)	BC174 BC171 BC172 BC171A/2A/4A BC171B/2B/4B BC172C		120 120 120 120 180 3B0	 180 290 520	450 800 800 220 460 B00	
(I_C = 100 mA, V_{CE} = 5 V)	BC171A/2A/4A BC171B/2B/4B BC172C			120 1B0 300		
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5 mA) (I_C = 10 mA, I_B = See Note 1)		$V_{CE(sat)}$		0.09 0.2 0.3	0.25 0.60 0.6	V
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA)		$V_{BE(sat)}$		0.7		V
Base-Emitter On Voltage (I_C = 2 mA, V_{CE} = 5 V) (I_C = 10 mA, V_{CE} = 5 V)		$V_{BE(on)}$	0.55		0.70 0.77	V

NOTE 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS, SMALL SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 5 V, f = 100 MHz)	BC171 BC172 BC174	f_T	150 150 150	300 300 300		MHz
Output Capacitance (V_{CB} = 10 V, I_C = 0, f = 1 MHz)		C_{obo}		1.7	4.5	pF
Input Capacitance (V_{BE} = 0.5 V, I_C = 0, f = 1 MHz)		C_{ibo}		10		pF
Input Impedance (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC171A/2A/4A BC171B/2B/4B BC172C	h_{ie}	1.6 3.2 6.0	2.7 4.5 8.7	4.5 8.5 15.0	Kohm
Voltage Feedback Ratio (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC171A/2A/4A BC171B/2B/4B BC172C	h_{re}		1.5 2.0 3.0		$X10^{-4}$
Small-Signal Current Gain (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC171A/2A/4A BC171B/2B/4B BC172C	h_{fe}	125 240 450	220 330 600	260 500 900	
Output Admittance (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC171A/2A/4A BC171B/2B/4B BC172C	h_{oe}		8 10 12	25 35 50	µmhos
Noise Figure (I_C = 0.2 mA, V_{CE} = 5 V, R_S = 2 KOhms, f = 1 KHz, Δf = 200 Hz)	BC171 BC172 BC174	NF		2 2 2	10 10 10	dB

BC182
BC183
BC184

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

P3-3

Refer to BC237 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 182	BC 183	BC 184	Unit
Collector-Emitter Voltage	V_{CEO}	50	30	30	Vdc
Collector-Base Voltage	V_{CBO}	60	45	45	Vdc
Emitter-Base Voltage	V_{EBO}		6.0		Vdc
Collector Current – Continuous	I_C		100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		350 2.8		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		1.0 B.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mA, I_B = 0)	8C1B2 8C183 BC184	$V_{(8R)CEO}$	50 30 30	— — —	— — —	V
Collector-8ase 8reakdown Voltage (I_C = 10 μA, I_E = 0)	BC182 BC183 BC184	$V_{(BR)CBO}$	60 45 45	— — —	— — —	V
Emitter-8ase Breakdown Voltage (I_E = 100 μA, I_C = 0)		$V_{(8R)EBO}$	6.0	—	—	V
Collector Cutoff Current (V_{C8} = 50 V, V_{BE} = 0) (V_{CB} = 30 V, V_{BE} = 0)	BC182 8C183 8C184	I_{C8O}	— — —	0.20 0.20 0.20	15 15 15	nA
(V_{CB} = 50 V, V_{BE} = 0) T_A = 125°C (V_{CB} = 30 V, V_{BE} = 0) T_A = 125°C	BC1B2 BC1B3 BC1B4		— — —	0.20 0.20 0.20	4 4 4	μA
Emitter-Base Leakage Current (V_{EB} = 4 V, I_C = 0)		I_{EBO}	—	—	15	nA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5 V)	8C1B2 BC183 BC1B4	h_{FE}	40 40 100	— — —	— — —	
(I_C = 2 mA, V_{CE} = 5 V)	BC182 BC183 BC184		100 100 250	— — —	480 850 850	
(I_C = 100 mA, V_{CE} = 5 V)	BC1B2 BC1B3 BC184		80 BO 130	— — —	— — —	
Collector-Emitter On Voltage (I_C = 10 mA, I_B = 5 mA) (I_C = 100 mA, I_B = 5 mA)*		$V_{CE(sat)}$	— —	0.07 0.20	0.25 0.60	V
Base-Emitter Saturation Voltage (I_C = 100 mA, I_B = 5 mA)		$V_{BE(sat)}$	—	1.05	—	V
Base-Emitter On Voltage (I_C = 100 μA, V_{CE} = 5 V) (I_C = 2 mA, V_{CE} = 5 V) (I_C = 100 mA, V_{CE} = 5 V)		$V_{BE(on)}$	— 0.55 —	0.50 0.62 0.83	— 0.70 —	V

* Pulse-test: Tp 300 s, Duty-cycle 2%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product		f_T				MHz
(I_C = 0.5 mA, V_{CE} = 3 V, f = 100 MHz)	BC182		—	100	—	
	BC183		—	120	—	
	BC184		—	140	—	
(I_C = 10 mA, V_{CE} = 5 V, f = 100 MHz)	BC182		150	200	—	
	BC183		150	240	—	
	BC184		150	280	—	
Common Base Output Capacitance (V_{CB} = 10 V, I_C = 0, f = 1 MHz)		C_{ob}	—	—	5.0	pF
Common Base Input Capacitance (V_{BE} = 0.5 V, I_C = 0, f = 1 MHz)		C_{ib}	—	8.0	—	pF
Input Impedance		h_{ie}				Kohm
(I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC182		1.6	2.2	4.5	
	BC183		3.2	6.0	8.5	
	BC184		6.0	8.7	15.0	
Voltage Feedback Ratio		h_{re}				$X10^{-4}$
(I_C = 2 mA, V_{CE} = 5, f = 1 KHz)	BC182		—	1.5	—	
	BC183		—	2.0	—	
	BC184		—	3.0	—	
Small-Signal Current Gain		h_{fe}				
(I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC182		125	—	500	
	BC183		125	—	900	
	BC184		240	—	900	
	BC182A, BC183A		125	—	260	
	BC182B, BC183B, BC184B		240	—	500	
	BC183C, BC184C		450	—	900	
Output Admittance		h_{oe}				μmhos
(I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC182		—	8	25	
	BC183		—	10	35	
	BC184		—	12	50	
Noise Figure		NF				dB
(I_C = 0.2 mA, V_{CE} = 5 V, R_S = 2 Kohms, f = 30 Hz to 15 KHz)	BC184		—	2	4	
(I_C = 0.2 mA, V_{CE} = 5 V, R_S = 2 Kohms, f = 1 KHz, f = 200 Hz)	BC182		—	2	10	
	BC183		—	2	10	
	BC184		—	2	4	

2

BC212
BC213
BC214

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

Refer to BC307 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 212	BC 213	BC 214	Unit
Collector-Emitter Voltage	V_{CEO}	50	30	30	Vdc
Collector-Base Voltage	V_{CBO}	60	45	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	BC212 BC213 BC214	$V_{(BR)CEO}$	50 30 30	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10μA, I_E = 0)	BC212 BC213 BC214	$V_{(BR)CBO}$	60 45 45	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100μAdc, I_C = 0)	BC212 BC213 BC214	$V_{(BR)EBO}$	6 5.5 5.5	— — —	— — —	Vdc
Collector-Emitter Leakage Current (V_{CB} = 30 V)	BC212 BC213 BC214	I_{CBO}	— — —	— — —	15 15 15	nAdc
(V_{CB} = 30 V T_A = 125°C)	BC212 BC213 BC214		— — —	— — —	4 4 4	μAdc
Emitter-Base Leakage Current (V_{EB} = 4 V, I_C = 0)	BC212 BC213 BC214	I_{EBO}	— — —	— — —	15 15 15	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5 Vdc)	BC212 BC213 BC214	h_{FE}	40 40 100	— — —	— — —	
(I_C = 2 mAdc, V_{CE} = 5 Vdc)	BC212 BC213 BC214		60 80 140	— — —	— — 600	
(I_C = 100 mAdc, V_{CE} = 5 Vdc)*	BC212, BC214 BC213		— —	120 140	— —	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 0.5 mAdc)			—	0.10	—	
(I_C = 100 mAdc, I_B = 5 mAdc)*			—	0.25	—	
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5 mAdc)		$V_{BE(sat)}$	—	1.00	—	Vdc
Base-Emitter on Voltage (I_C = 2 mAdc, V_{CE} = 5 Vdc)		$V_{BE(on)}$	0.55	0.62	0.70	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 50 MHz)	BC212	f_T	—	280	—	MHz
	BC214		—	320	—	
	BC213		—	360	—	
Common-Base Output Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = MHz)		C_{ob}	—	—	6.0	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5 Vdc, R_S = 2 Kohms, f = 30 Hz to 15 KHz)	BC214	NF	—	—	2	dB
(I_C = 0.2 mAdc, V_{CE} = 5 Vdc, R_S = 2 Kohms, f = 1 KHz, f = 200 Hz)	BC213		—	—	10	
	BC212		—	—	10	
Input Impedance I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC212	h_{ie}	0.4	2.0	3.0	kΩ
	BC213		1.2	2.7	4.5	
	BC214		3.0	4.5	8.0	
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC212	h_{re}	—	2.5	—	10^{-4}
	BC213		—	3.0	—	
	BC214		—	3.5	—	
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC212	h_{fe}	60	—	—	
	BC213		80	—	—	
	BC214		140	—	—	
	BC212A, BC213A		100	—	300	
	BC212B, BC213B,		200	—	400	
	BC214B		200	—	400	
	BC213C, BC214C		350	—	600	
Output Admittance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC212	h_{oe}	—	20	40	μ mhos
	BC213		—	25	50	
	BC214		—	30	70	

*Pulse-test: Tp 300 s, Duty-cycle 2%.

BC237
BC238
BC239

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 237	BC 238	BC 239	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	25	Vdc
Collector-Emitter Voltage	V_{CES}	50	30	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	5.0	5.0	Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8			mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 2.0$ mA, $I_B = 0$)	BC237 BC238 BC239	$V_{(BR)CEO}$	45 25 25			V
Emitter-Base Breakdown Voltage ($I_E = 100$ μA, $I_C = 0$)	BC237 BC238 BC239	$V_{(BR)EBO}$	6 5 5			V
Collector Cutoff Current ($V_{CE} = 30$ V, $V_{BE} = 0$) ($V_{CE} = 50$ V, $V_{BE} = 0$)	BC238 BC239 BC237	I_{CES}		0.20 0.20 0.20	15 15 15	nA
($V_{CE} = 30$ V, $V_{BE} = 0$) $T_A = 125°C$ ($V_{CE} = 50$ V, $V_{BE} = 0$) $T_A = 125°C$	BC238 BC239 BC237			0.20 0.20 0.20	4 4 4	μA
ON CHARACTERISTICS						
DC Current Gain ($I_C = 10$ μA, $V_{CE} = 5$ V)	BC237A/238A BC237B/238B/239B BC237C/238C/239C	h_{FE}		90 150 270		
($I_C = 2$ mA, $V_{CE} = 5$ V)	BC237 BC238 BC239 BC237A/238A BC237B/238B/239B BC237C/238C/239C		120 120 120 120 180 380	 170 290 500	800 800 800 220 460 800	
($I_C = 100$ mA, $V_{CE} = 5$ V)	BC237A/238A BC237B/238B/239B BC237C/238C/239C			120 180 300		
Collector-Emitter On Voltage ($I_C = 10$ mA, $I_B = 0.5$ mA) ($I_C = 100$ mA, $I_B = 5$ mA)	BC237/BC238/BC239 BC237/BC239 BC238	$V_{CE(sat)}$		0.07 0.20	0.20 0.60 0.8	V
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 0.5$ mA) ($I_C = 100$ mA, $I_B = 5$ mA)		$V_{BE(sat)}$		0.60	0.83 1.05	V
Base-Emitter On Voltage ($I_C = 100$ μA, $V_{CE} = 5$ V) ($I_C = 2$ mA, $V_{CE} = 5$ V) ($I_C = 100$ mA, $V_{CE} = 5$ V)		$V_{BE(on)}$	 0.55	0.50 0.62 0.83	 0.70	V

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product		f_T				MHz
(I_C = 0.5 mA, V_{CE} = 3 V, f = 100 MHz)	BC237			100		
	BC238			120		
	BC239			140		
(I_C = 10 mA, V_{CE} = 5 V, f = 100 MHz)	BC237		150	200		
	BC238		150	240		
	BC239		150	280		
Collector-Base Capacitance (V_{CB} = 10 V, I_C = 0, f = 1 MHz)		C_{obo}			4.50	pF
Emitter-Base Capacitance (V_{BE} = 0.5 V, I_C = 0, f = 1 MHz)		C_{ibo}		8.0		pF
Input Impedance		h_{ie}				Kohm
(I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC237A/238A		1.6	2.2	4.5	
	BC237B/238B/239B		3.2	6.0	8.5	
	BC237C/238C/239C		6.0	8.7	15.0	
Voltage Feedback Ratio		h_{re}				$X10^{-4}$
(I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC237A/238A			1.5		
	BC2378/2388/239B			2.0		
	BC237C/238C/239C			3.0		
Small-Signal Current Gain		h_{fe}				
(I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC237A/238A		125	220	260	
	BC237B/238B/239B		240	330	500	
	BC237C/238C/239C		450	600	900	
Output Admittance		h_{oe}				μmhos
(I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	8C237A/238A			8	30	
	BC237B/2388/239B			10	60	
	BC237C/238C/239C			12	110	
Noise Figure		NF				dB
(I_C = 0.2 mA, V_{CE} = 5 V, R_S = 2 Kohms, f = 30 Hz to 15 KHz)	BC239			2	4	
(I_C = 0.2 mA, V_{CE} = 5 V, R_S = 2 Kohms, f = 1 KHz, Δf = 200 Hz)	BC237			2	10	
	BC238			2	10	
	8C239			2	4	

FIGURE 1 NORMALIZED DC CURRENT GAIN

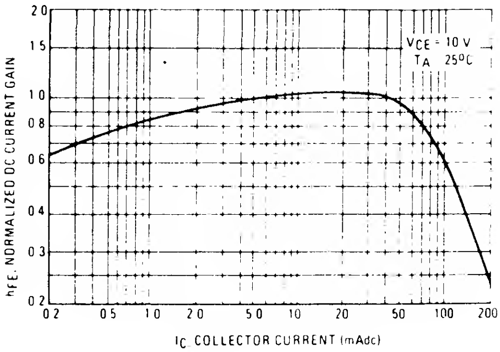


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

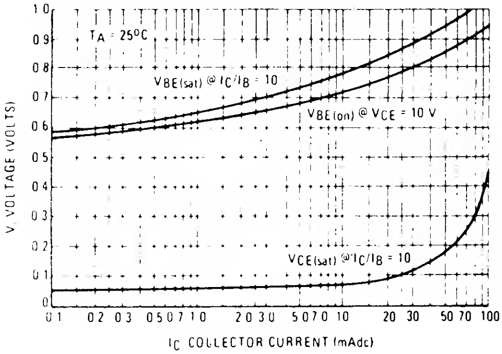


FIGURE 3 – CURRENT GAIN-BANDWIDTH PRODUCT

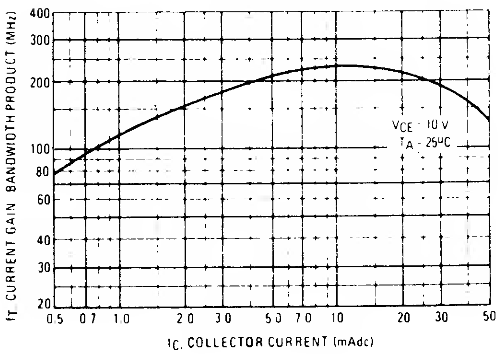


FIGURE 4 – CAPACITANCES

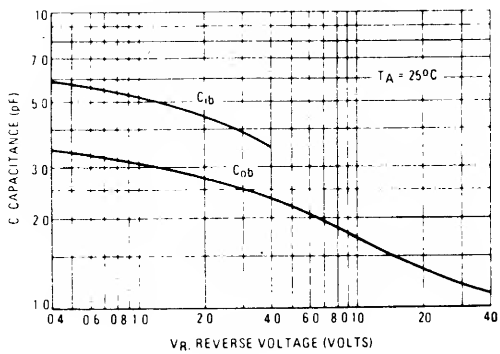


FIGURE 5 – OUTPUT ADMITTANCE

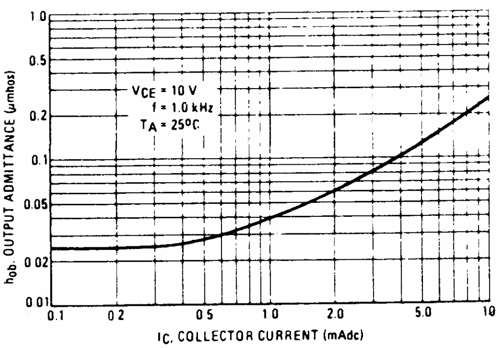
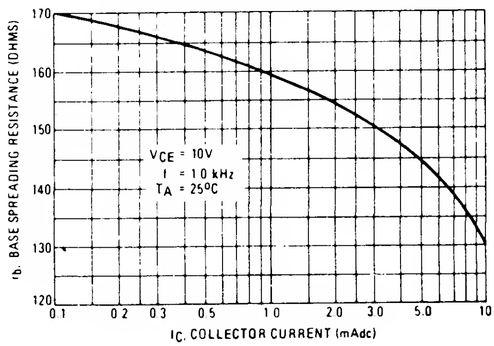


FIGURE 6 – BASE SPREADING RESISTANCE



BC256
BC251
BC252

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BC 256	BC 251	BC 252	Unit
Collector-Emitter Voltage	V_{CEO}	65	45	30	Vdc
Collector-Base Voltage	V_{CBO}	80	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

Refer to BC556 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mA, I_B = 0)	BC256 BC251 BC252	$V_{(BR)CEO}$	65 45 30			V
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)	BC256 BC251 BC252	$V_{(BR)EBO}$	5 5 5			V
Collector-Emitter Leakage Current (V_{CES} = 40 V) (V_{CES} = 20 V)	BC256 BC251 BC252	I_{CES}		2 2 2	100 100 100	nA
(V_{CES} = 20 V, T_A = 125°C)	BC256 BC251 BC252				4 4 4	μA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5 V)	BC251A/2A/6A BC251B/2B/6B BC252C	h_{FE}		90 150 270		
(I_C = 2 mA, V_{CE} = 5 V)	BC256 BC251 BC252 BC251A/2A/6A BC251B/2B/6B BC252C		125 120 120 120 180 380	 170 290 500	500 800 800 220 460 800	
(I_C = 100 mA, V_{CE} = 5 V)	BC251A/2A/6A BC251B/2B/6B BC252C			120 180 300		
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 10 mA, I_B = see Note 1) (I_C = 100 mA, I_B = 5 mA)		$V_{CE(sat)}$		0.075 0.30 0.25	0.3 0.60 0.65	V
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5 mA)		$V_{BE(sat)}$		0.70 1.00		V
Base-Emitter on Voltage (I_C = 2 mA, V_{CE} = 5 V) (I_C = 10 mA, V_{CE} = 5 V)		$V_{BE(on)}$	0.55	0.62 0.7	0.70 0.82	V

NOTE 1: I_C mAdc on the constant base current characteristic, which yields the point I_C = 11 mAdc, V_{CE} = 1 V.

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 5 V, f = 50 MHz)		f_T				MHz
	BC256			280		
	BC251			320		
	BC252			360		
Output Capacitance (V_{CB} = 10 V, I_C = 0, f = 1 MHz)		C_{ob}		3	6.0	pF
Noise Figure (I_C = 0.2 mA, V_{CE} = 5 V, R_S = 2 Kohms, f = 1 KHz, Δf = 200 Hz)		NF				dB
	BC256			2	10	
	BC251			2	10	
	BC252			2	10	
Input Impedance (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)		h_{ie}				kΩ
	BC251A/2A/4A		1.2	2.7	4.5	
	BC251B/2B/4B		3.0	4.5	8.0	
	BC252C		5.0	8.0	14.0	
Voltage Feedback Ratio (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)		h_{re}				10^{-4}
	BC251A/2A/4A			3.0		
	BC251B/2B/4B			3.5		
	BC252C			4.0		
Small-Signal Current Gain (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)		h_{fe}				
	BC256		125		500	
	BC251/2		125		900	
	BC251A/2A/6A		125	220	260	
	BC251B/2B/6B		240	330	500	
	BC252C		450	600	900	
Output Admittance (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)		h_{oe}				µmhos
	BC251A/2A/6A			25	50	
	BC251B/2B/6B			30	70	
	BC252C			60	110	

BC307
BC308
BC309

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 307	BC 308	BC 309	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current – Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	BC307 BC308 BC309	$V_{(BR)CEO}$	45 25 25	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BC307 BC308 BC309	$V_{(BR)EBO}$	5 5 5	— — —	— — —	Vdc Vdc
Collector-Emitter Leakage Current (V_{CES} = 50 V, V_{BE} = 0) (V_{CES} = 30 V, V_{BE} = 0) (V_{CES} = 50 V, V_{BE} = 0) T_A = 125°C (V_{CES} = 30 V, V_{BE} = 0) T_A = 125°C	BC307 BC308 BC309 BC307 BC308 BC309	I_{CES}		0.2 0.2 0.2 0.2 0.2 0.2	15 15 15 4.0 4.0 4.0	nA μA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5 Vdc)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C	h_{FE}	— — —	90 150 270	— — —	
(I_C = 2 mAdc, V_{CE} = 5 Vdc)	BC307 BC308 BC309 BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C		120 120 120 120 180 380	— — — 170 290 500	800 800 800 220 460 800	
(I_C = 100 mAdc, V_{CE} = 5 Vdc)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C		— — —	120 180 300	— — —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0,5 mAdc) (I_C = 10 mAdc, I_B = see Note 1) (I_C = 100 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$	— — —	0.10 0.30 0.25	0.30 0.60 —	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 100 mAdc, I_B = 5 mAdc)		$V_{BE(sat)}$	— —	0.70 1.00	— —	Vdc
Base-Emitter on Voltage (I_C = 2 mAdc, V_{CE} = 5 Vdc)		$V_{BE(on)}$	0.55	0.62	0.70	Vdc

Note 1: I_C = 10 mAdc on the constant base current characteristic, which yields the point I_C = 11 mAdc, V_{CE} = 1 V

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ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 50 MHz)	BC307 BC308 BC309	f_T	— — —	280 320 360	— — —	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = 1 MHz)		C_{cbo}	—	—	6.0	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5 Vdc, R_S = 2 Kohms, f = 30 Hz to 15 KHz)	BC309	NF	—	2	4	dB
(I_C = 0.2 mAdc, V_{CE} = 5 Vdc, R_S = 2 Kohms, f = 1 KHz, f = 200 Hz)	BC307 BC308 BC309		— — —	2 2 2	10 10 4	
Input Impedance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C	h_{ie}	1.2 3.0 5.0	2.7 4.5 8.0	4.5 8.0 15	kΩ
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C	h_{re}	— — —	3.0 3.5 4.0	— — —	10^{-4}
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C	h_{fe}	125 240 450	220 330 600	260 500 900	—
Output Admittance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC307A/308A/309A BC307B/308B/309B BC307C/308C/309C	h_{oe}	— — —	25 30 60	50 70 110	μmhos

FIGURE 1 – NORMALIZED DC CURRENT GAIN

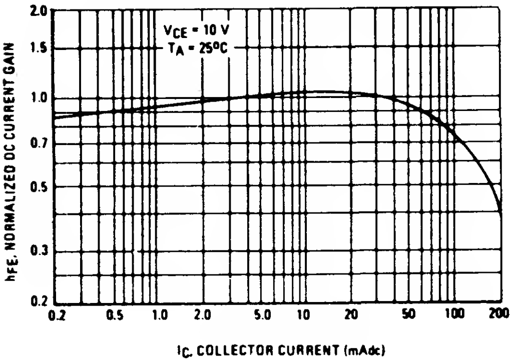


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

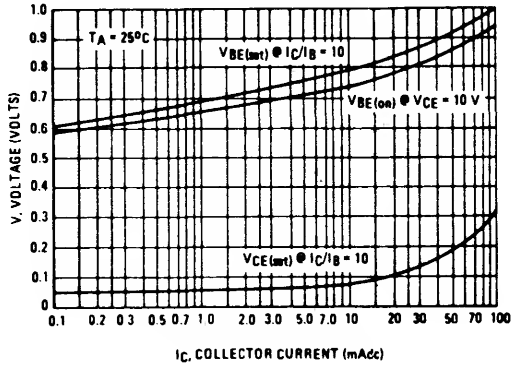


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

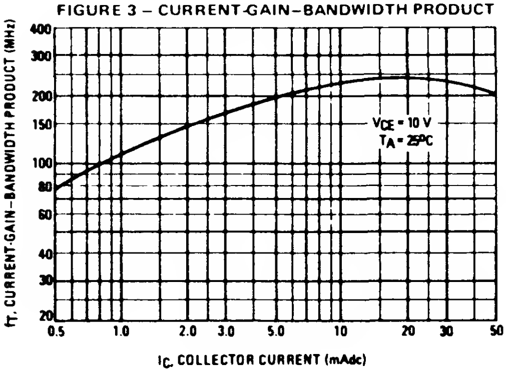


FIGURE 4 – CAPACITANCES

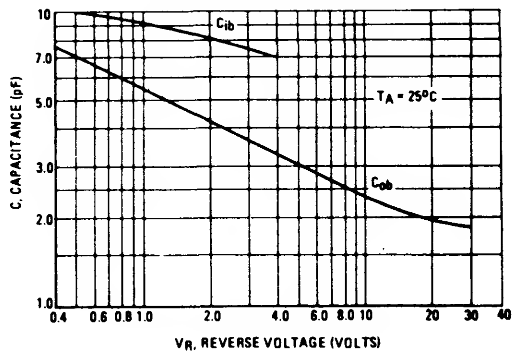


FIGURE 5 – OUTPUT ADMITTANCE

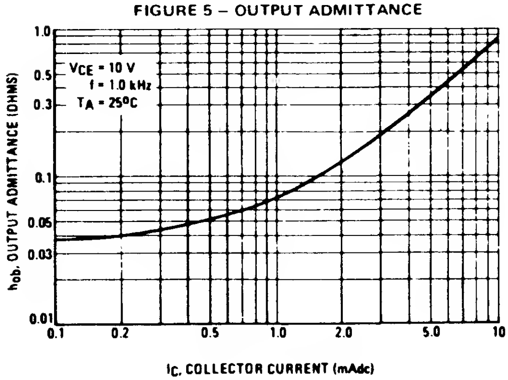
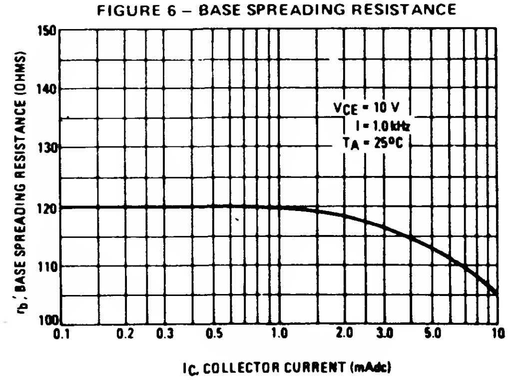


FIGURE 6 – BASE SPREADING RESISTANCE



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BC317, A, B
BC318, A, B, C
BC319, A, B

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

Refer to BC549 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 317	BC 318	BC 319	Unit
Collector-Emitter Voltage	V_{CEO}	45	30	20	Vdc
Collector-Base Voltage	V_{CBO}	50	40	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	5.0	5.0	Vdc
Collector Current − Continuous	I_C	150			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R\ _{JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage I_C = 1 mA, I_B = 0	BC317 BC318 BC319	$V_{(BR)CEO}$	45 30 20			Vdc
Collector-Emitter Breakdown Voltage I_C = 100 μA, V_{BE} = 0	BC317 BC318 BC319	$V_{(BR)CES}$	50 40 30			Vdc
Collector-Base Breakdown Voltage I_C = 100 μA, I_E = 0	BC317 BC318 BC319	$V_{(BR)CBO}$	50 40 30			Vdc
Emitter-Base Breakdown Voltage I_E = 100 μA, I_C = 0	BC317 BC318 BC319	$V_{(BR)EBO}$	6 5 5			Vdc
Collector Cutoff Current V_{CB} = 20 V, I_E = 0		I_{CBO}			30	nAdc
ON CHARACTERISTICS						
Base-Emitter on Voltage I_C = 2 mA, V_{CE} = 5 V I_C = 10 mA, V_{CE} = 5 V		$V_{BE(on)}$	0.57	0.63	0.72 0.77	Vdc
Collector-Emitter Saturation Voltage I_C = 100 mA, I_B = 5 mA		$V_{CE(sat)}$		0.14	0.50	Vdc
Base-Emitter Saturation Voltage I_C = 10 mA, I_B = 0.5 mA I_C = 100 mA, I_B = 5 mA		$V_{BE(sat)}$		0.70 0.85		Vdc
DC Current Gain I_C = 10 μA, V_{CE} = 5 V	BC317A BC318A BC317B BC318B BC319B BC318C BC319C	h_{FE}	— — 40 40 40 100 100	90 90 150 150 150 270 270	— — — — — — —	
I_C = 2 mA, V_{CE} = 5 V	BC317A BC318A BC317B BC318B BC319B BC318C BC319C		110 110 200 200 200 420 420	180 180 290 290 290 520 520	220 220 450 450 450 800 800	

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ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Spot Noise Figure I_C = 200 μA, V_{CE} = 5 V R_S = 2 KΩ, f = 1 KHz, B.W. = 200 Hz	BC317 BC318 BC319	NF		2 2 1.5	6 6 4	dB
Wide Band Noise Figure I_C = 200 μA, V_{CE} = 5 V R_S = 2 KΩ, B.W. = 30 Hz to 15 KHz	BC319	NF		1.8	4	dB
Output Capacitance V_{CB} = 10 V, I_E = 0 f = 1 MHz		C_{ob}		2.5	4	pF
Input Capacitance V_{EB} = 0.5 V, I_C = 0 f = 1 MHz		C_{ib}		11.5		pF
Current-Gain-Bandwidth Product I_C = 10 mA, V_{CE} = 5 V		f_T		280		MHz
Voltage Feedback Ratio I_C = 2 mA, V_{CE} = 5 V f = 1 KHz		h_{re}		2.0		$X10^{-4}$
Input Impedance I_C = 2 mA, V_{CE} = 5 V f = 1 KHz		h_{ie}		5.0		Kohms
Output Admittance I_C = 2 mA, V_{CE} = 5 V f = 1 KHz		h_{oe}		20		μmhos
Small Signal Current Gain I_C = 2 mA, V_{CE} = 5 V f = 1 KHz	BC317A BC318A BC317B BC318B BC319B BC318C BC319C	h_{fe}	125 125 240 240 240 450 450	220 220 330 330 330 600 600	260 260 500 500 500 900 900	

BC320, A, B
BC321, A, B
BC322, B

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

Refer to BC559 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 320	BC 321	BC 322	Unit
Collector-Emitter Voltage	V_{CEO}	45	30	20	Vdc
Collector-Base Voltage	V_{CBO}	50	40	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	5.0	5.0	Vdc
Collector Current − Continuous	I_C	150			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage I_C = 1 mA, I_B = 0	BC320 BC321 BC322	$V_{(BR)CEO}$	45 30 20			Vdc
Collector-Emitter Breakdown Voltage I_C = 100 μA, V_{BE} = 0	BC320 BC321 BC322	$V_{(BR)CES}$	50 40 30			Vdc
Collector-Base Breakdown Voltage I_C = 100 μA, I_E = 0	BC320 BC321 BC322	$V_{(BR)CBO}$	50 40 30			Vdc
Emitter-Base Breakdown Voltage I_E = 100 μA, I_C = 0	BC320 BC321 BC322	$V_{(BR)EBO}$	6 5 5			Vdc
Collector Cutoff Current V_{CB} = 20 V, I_E = 0		I_{CBO}			30	nAdc
ON CHARACTERISTICS						
Base-Emitter on Voltage I_C = 2 mA, V_{CE} = 5 V I_C = 10 mA, V_{CE} = 5 V		$V_{BE(on)}$	0.57	0.68	0.72 0.77	Vdc
Collector-Emitter Saturation Voltage I_C = 100 mA, I_B = 5 mA		$V_{CE(sat)}$		0.35	0.50	Vdc
Base-Emitter Saturation Voltage I_C = 10 mA, I_B = 0.5 mA I_C = 100 mA, I_B = 5 mA		$V_{BE(sat)}$		0.77 0.99		Vdc
DC Current Gain I_C = 10 μA, V_{CE} = 5 V	BC320A BC321A BC320B BC321B BC322B	h_{FE}	— — 40 40 40	50 50 100 100 100	— — — — —	
I_C = 2 mA, V_{CE} = 5 V	BC320A BC321A BC320B BC321B BC322B		110 110 200 200 200	180 180 290 290 290	220 220 450 450 450	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Spot Noise Figure I_C = 200 μA, V_{CE} = 5 V R_S = 2 KΩ, f = 1 KHz, B.W. = 200 Hz	BC320 BC321 BC322	NF		2 2 1.5	6 6 4	dB
Wide Band Noise Figure I_C = 200 μA, V_{CE} = 5 V R_S = 2 KΩ, B.W. = 30 Hz to 15 KHz	BC322	NF		1.B	4	dB
Output Capacitance V_{CB} = 10 V, I_E = 0 f = 1 MHz		C_{ob}		3	4	pF
Input Capacitance V_{EB} = 0.5 V, I_C = 0 f = 1 MHz		C_{ib}		16		pF
Current-Gain-Bandwidth Product I_C = 10 mA, V_{CE} = 5 V		f_T		250		MHz
Voltage Feedback Ratio I_C = 2 mA, V_{CE} = 5 V f = 1 KHz		h_{re}		2.0		$X10^{-4}$
Input Impedance I_C = 2 mA, V_{CE} = 5 V f = 1 KHz		h_{ie}		1.6		Kohms
Output Admittance I_C = 2 mA, V_{CE} = 5 V f = 1 KHz		h_{oe}		30		μmhos
Small Signal Current Gain I_C = 2 mA, V_{CE} = 5 V f = 1 KHz	BC320A BC321A BC320B BC321B BC322B	h_{fe}	125 125 240 240 240	220 220 290 290 290	260 260 500 500 500	

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BC327
BC328

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 327	BC 328	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current – Continuous	I_C	800		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage $I_C = 10$ mA, $I_B = 0$	BC327 BC328	$V_{(BR)CEO}$	45 25			Vdc
Collector-Base Breakdown Voltage $I_C = 10$ µA, $I_E = 0$	BC327 BC328	$V_{(BR)CBO}$	50 30			Vdc
Emitter-Base Breakdown Voltage $I_E = 10$ µA, $I_C = 0$		$V_{(BR)EBO}$	5			Vdc
Collector Cutoff Current BC327 – $V_{CB} = 30$ V, $I_E = 0$ BC328 – $V_{CB} = 20$ V, $I_E = 0$		I_{CBO}			100	nAdc
Emitter Cutoff Current $V_{EB} = 4$ V, $I_C = 0$		I_{EBO}			100	nAdc
ON CHARACTERISTICS						
DC Current Gain $I_C = 100$ mA, $V_{CE} = 1$ V	BC327/BC328 BC327-16/BC328-16 BC327-25/BC328-25 BC327-40/BC328-40	h_{FE}	100 100 160 250		600 250 400 630	
$I_C = 300$ mA, $V_{CE} = 1$ V			40			
Base-Emitter On Voltage $I_C = 300$ mA, $V_{CE} = 1$ V		$V_{BE(on)}$			1.2	Vdc
Collector-Emitter Saturation Voltage $I_C = 500$ mA, $I_B = 50$ mA		$V_{CE(sat)}$			0.7	Vdc
SMALL SIGNAL CHARACTERISTICS						
Output Capacitance $V_{CB} = 10$ V, $I_E = 0$ f = 1 MHz		C_{ob}		5		pF
Current-Gain-Bandwidth Product $I_C = 10$ mA, $V_{CE} = 5$ V		f_T		260		MHz

FIGURE 1 – THERMAL RESPONSE

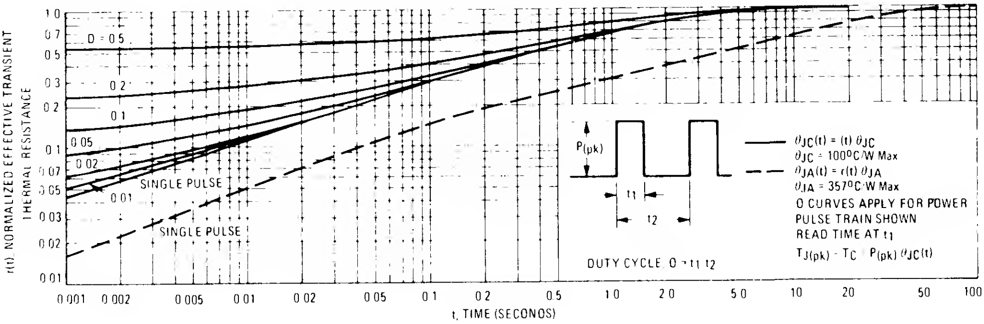


FIGURE 2 – ACTIVE REGION SAFE OPERATING AREA

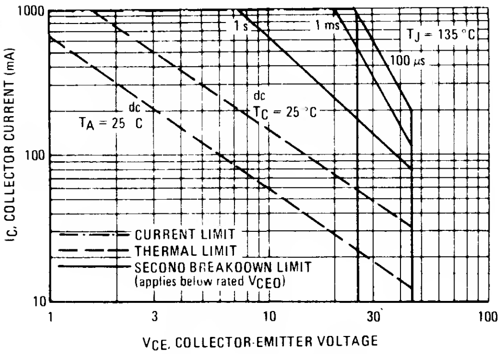


FIGURE 3 – DC CURRENT GAIN

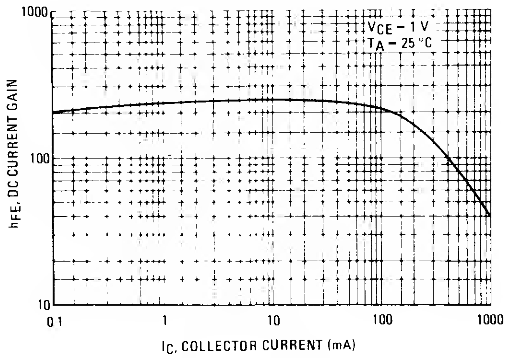


FIGURE 4 – SATURATION REGION

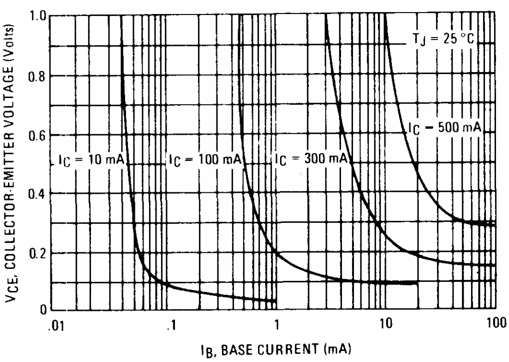


FIGURE 5 – "ON" VOLTAGES

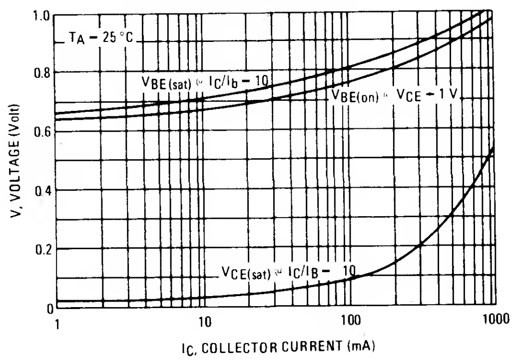


FIGURE 6 – TEMPERATURE COEFFICIENTS

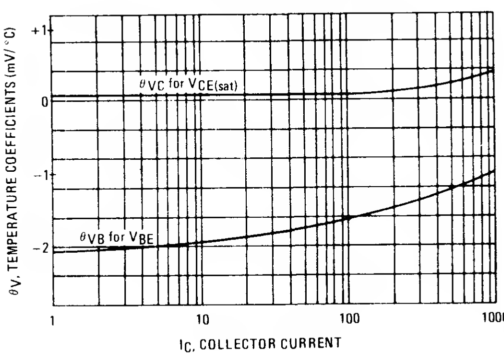
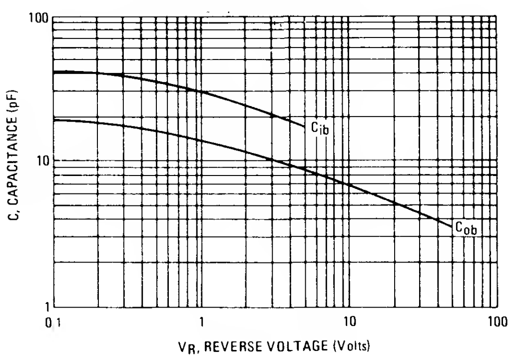


FIGURE 7 – CAPACITANCES



2

BC337
BC338

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 337	BC 338	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current – Continuous	I_C	800		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage I_C = 10 mA, I_B = 0	BC337 BC338	$V_{(BR)CEO}$	45 25			Vdc
Collector-Base Breakdown Voltage I_C = 10 μA, I_E = 0	BC337 BC338	$V_{(BR)CBO}$	50 30			Vdc
Emitter-Base Breakdown Voltage I_E = 10 μA, I_C = 0		$V_{(BR)EBO}$	5			Vdc
Collector Cutoff Current BC337 – V_{CB} = 30 V, I_E = 0 BC338 – V_{CB} = 20 V, I_E = 0		I_{CBO}			100	nAdc
Emitter Cutoff Current V_{EB} = 4 V, I_C = 0		I_{EBO}			100	nAdc
ON CHARACTERISTICS						
DC Current Gain I_C = 100 mA, V_{CE} = 1 V I_C = 300 mA, V_{CE} = 1 V	 BC337/BC338 BC337-16/BC338-16 BC337-25/BC338-25 BC337-40/BC338-40	h_{FE}	 100 100 160 250 60		 600 250 400 630	
Base-Emitter On Voltage I_C = 300 mA, V_{CE} = 1 V		$V_{BE(on)}$			1.2	Vdc
Collector-Emitter Saturation Voltage I_C = 500 mA, I_B = 50 mA		$V_{CE(sat)}$			0.7	Vdc
SMALL SIGNAL CHARACTERISTICS						
Output Capacitance V_{CB} = 10 V, I_E = 0 f = 1 MHz		C_{ob}		4		pF
Current-Gain-Bandwidth Product I_C = 10 mA, V_{CE} = 5 V		f_T		210		MHz

FIGURE 1 – THERMAL RESPONSE

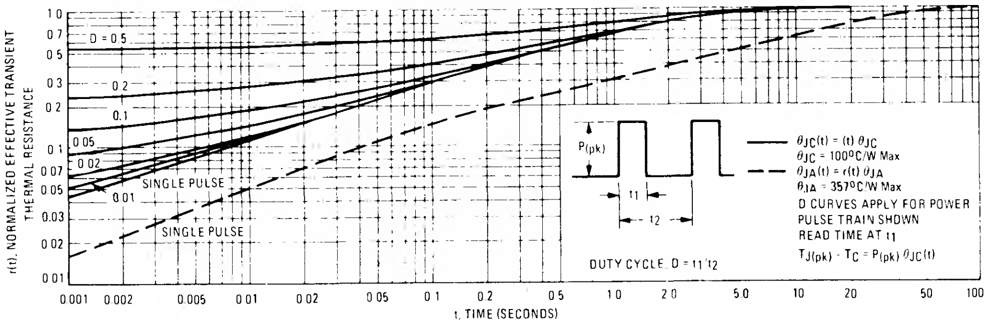


FIGURE 2 – ACTIVE REGION SAFE OPERATING AREA

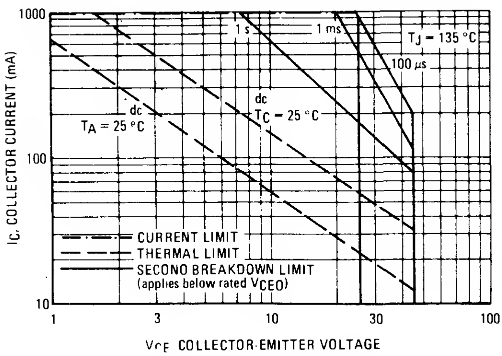


FIGURE 3 – DC CURRENT GAIN

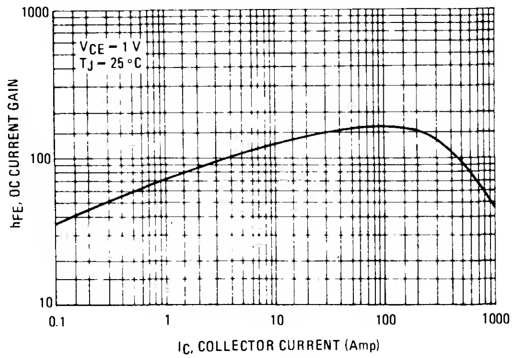


FIGURE 4 – SATURATION REGION

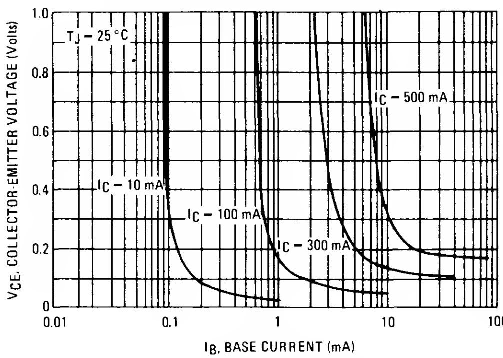


FIGURE 5 – "ON" VOLTAGES

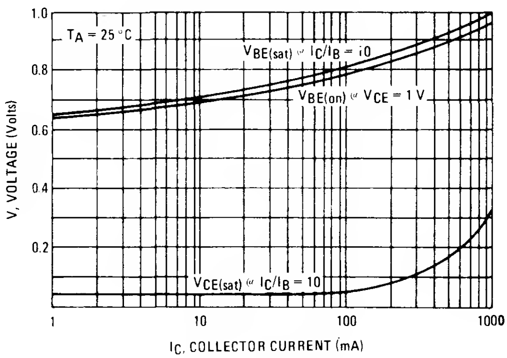


FIGURE 6 – TEMPERATURE COEFFICIENTS

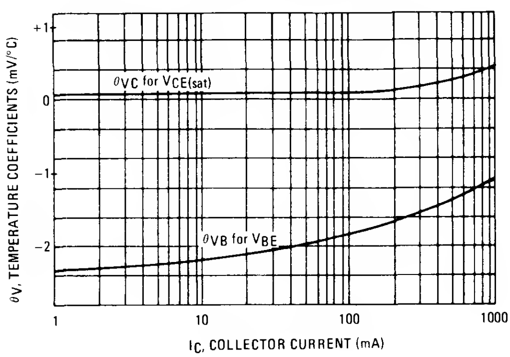
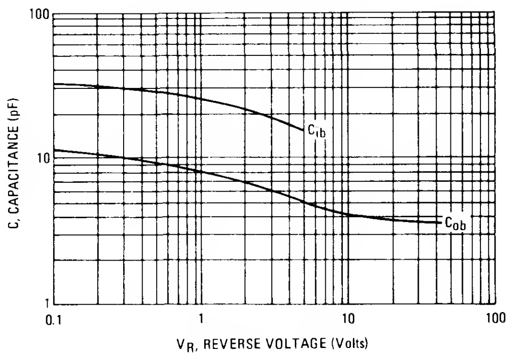


FIGURE 7 – CAPACITANCES



BC368 (NPN)
BC369 (PNP)

CASE 29-02, STYLE 14
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 6.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.75 22	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	45	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	156	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage I_C = 10 mA, I_B = 0	$V_{(BR)CEO}$	20			Vdc
Collector-Base Breakdown Voltage I_C = 100 uA, I_E = 0	$V_{(BR)CBO}$	25			Vdc
Emitter-Base Breakdown Voltage I_E = 100 uA, I_C = 0	$V_{(BR)EBO}$	5			Vdc
Collector Cutoff Current V_{CB} = 25 V, I_E = 0	I_{CBO}			10	µAdc
Emitter Cutoff Current V_{EB} = 5 V, I_C = 0	I_{EBO}			10	µAdc
ON CHARACTERISTICS					
DC Current Gain V_{CE} = 10 V, I_C = 5 mA V_{CE} = 1 V, I_C = 0.5 A V_{CE} = 1 V, I_C = 1 A	h_{FE}	50 85 60		375	
Bandwidth product V_{CE} = 5 V, I_C = 10 mA	f_T	65			Mhz
Collector emitter saturation voltage I_C = 1 A, I_B = 100 mA	$V_{CE(sat)}$			0.5	V

BC368 (NPN), BC369 (PNP)

FIGURE 1 — DC CURRENT GAIN

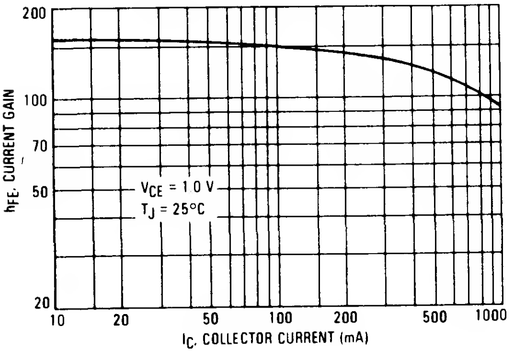


FIGURE 2 — COLLECTOR SATURATION REGION

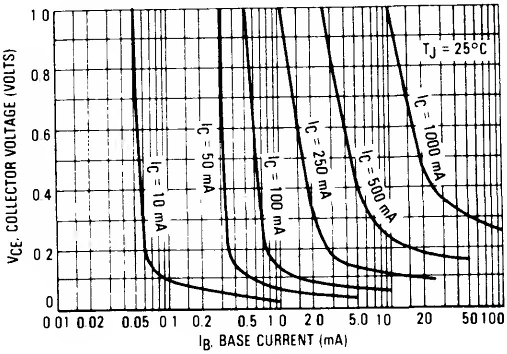


FIGURE 3 — ON VOLTAGES

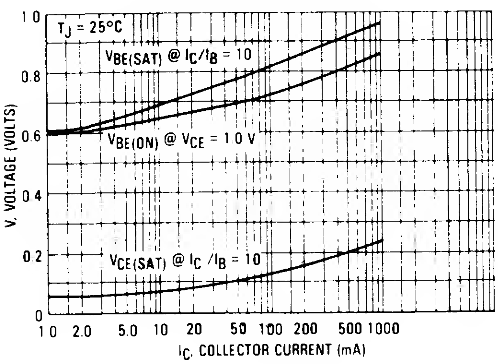


FIGURE 4 — TEMPERATURE COEFFICIENT

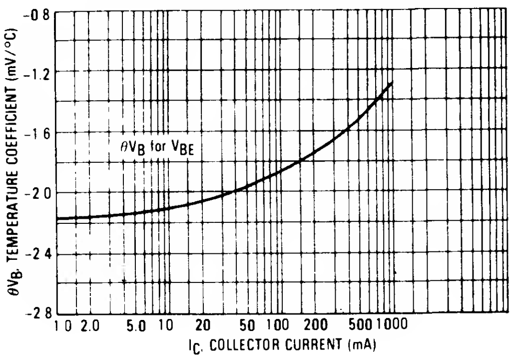


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

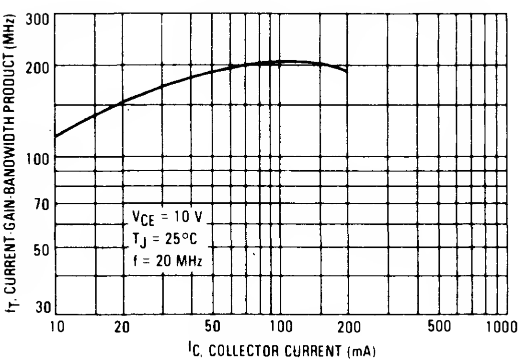
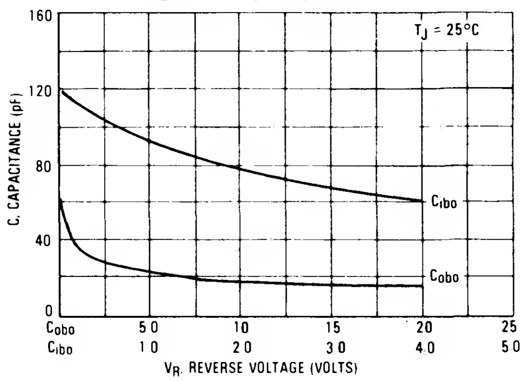


FIGURE 6 — CAPACITANCE



2

BC372
BC373

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE DARLINGTON

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 372	BC 373	Unit
Collector-Emitter Voltage	V_{CEO}	100	80	Vdc
Collector-Base Voltage	V_{CBO}	100	80	Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 100 μAdc, I_B = 0) BC372 BC373	$V_{(BR)CES}$	 100 80			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) BC372 BC373	$V_{(BR)CBO}$	 100 80			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	 12			Vdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0) BC372 (V_{CB} = 60 Vdc, I_E = 0) BC373	I_{CBO}			 100 100	nAdc
Emitter Cutoff Current (V_{BE} = 10 V, I_C = 0)	I_{EBO}			 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5 Vdc) plain range — 16 — 25 — 40 (I_C = 250 mAdc, V_{CE} = 5 Vdc) plain range — 16 — 25 — 40	h_{FE}	 8 8 20 40 10 10 25 60		 200 200 200 200 600 60 160 600	K
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 0.25 mAdc)	$V_{CE(sat)}$		0.8	1	Vdc
Base-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 0.25 mAdc)	$V_{BE(sat)}$		1.4	2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	f_T	100	200		MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}		10	25	pF
Noise Figure (I_C = 1 mAdc, V_{CE} = 5 Vdc, R_g = 100 Kohm, F = 1 KHz)	NF		2.0		dB

* Pulse test – Pulse width = 300 μs – Duty cycle 2%.

BC372, BC373

FIGURE 1 – DC CURRENT GAIN

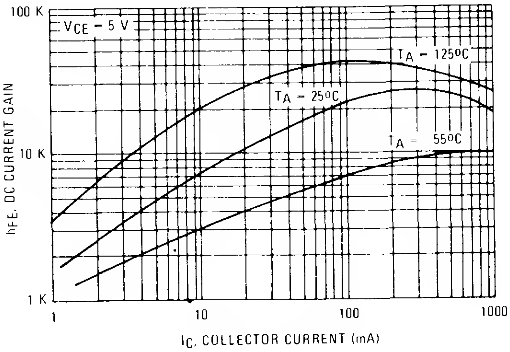


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

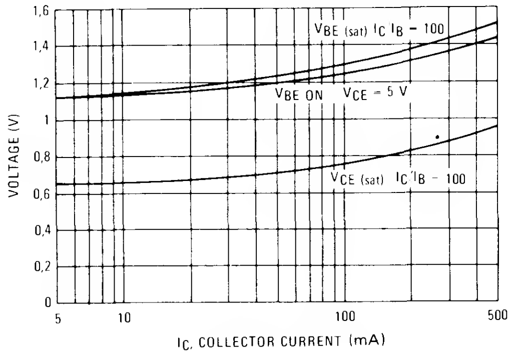


FIGURE 3 – CURRENT GAIN BANDWIDTH PRODUCT

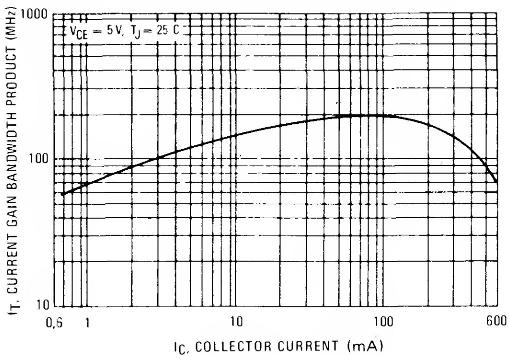
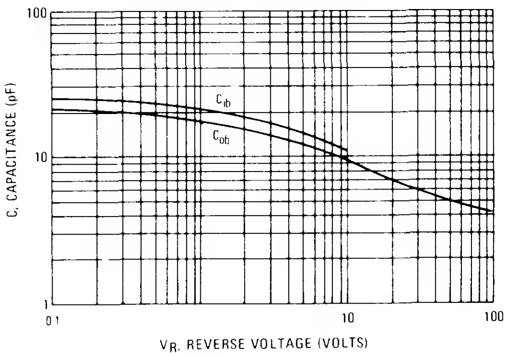


FIGURE 4 – CAPACITANCES



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2

BC413
BC414

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

LOW NOISE TRANSISTORS

NPN SILICON

Refer to BC549 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 413	BC 414	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	Vdc
Collector-Base Voltage	V_{CBO}	45	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current − Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0) BC413 BC414	$V_{(BR)CEO}$	30 45			Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0) BC413 BC414	$V_{(BR)CBO}$	45 50			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5			Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = +125°C)	I_{CBO}			15 5	nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)	I_{EBO}			15	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5 Vdc) BC413B/BC414B BC413C/BC414C (I_C = 2 mAdc, V_{CE} = 5 Vdc) BC413B/BC414B BC413C/BC414C BC413/BC414	h_{FE}	100 100 180 380 180	150 270 290 500 350	 460 800 800	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 10 mAdc, I_B = see note 1) (I_C = 100 mAdc, I_B = 5 mAdc, see note 2)	$V_{CE(sat)}$		0.075 0.3 0.25	0.25 0.6 0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5 mAdc)	$V_{BE(sat)}$		1.1		Vdc
Base-Emitter On Voltage (I_C = 10 μAdc, V_{CE} = 5 Vdc) (I_C = 100 μAdc, V_{CE} = 5 Vdc) (I_C = 2 mAdc, V_{CE} = 5 Vdc)	$V_{BE(on)}$	 0.55	0.52 0.55 0.62	 0.75	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	f_T		250		MHz
Collector-Base Capacitance (V_{CE} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{cbo}		2.5		pF

Note 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V

Note 2: Pulse test = 300 μs − Duty cycle = 2%

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Typ.	Max.	Unit
Input Impedance (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC413B/BC414B	h_{ie}	3.2	6.0	8.5	KΩ
	BC413C/BC414C		6.0	8.7	15.0	
Voltage Feedback Ratio (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC413B/BC414B	h_{re}		2.		10^{-4}
	BC413C/BC414C			3.		
Small Signal Current Gain (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC413B/BC414B	h_{fe}	240	330	500	
	BC413C/BC414C		450	600	900	
Output Admittance (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC413B/BC414B	h_{oe}		10	60	μmhos
	BC413C/BC414C			12	110	
Noise Figure (I_C = 200 μAdc, V_{CE} = 5 Vdc, R_S = 2 KΩ, f = 30 Hz − 15 KHz)		NF		0.6	2.5	dB
Equivalent Input Noise Voltage (I_C = 200 μAdc, V_{CE} = 5 V, R_S = 2 kΩ, f = 120 Hz)		V_T		8.0	12	nV/$\sqrt{Hz}$
Equivalent Input Noise Voltage (I_C = 200 μAdc, V_{CE} = 5 V, R_S = 2 KΩ, f = 10 Hz − 50 Hz)		V_T		74	135	nV/$\sqrt{Hz}$

2

BC415
BC416

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

LOW NOISE TRANSISTORS

PNP SILICON

Refer to BC559 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 415	BC 416	Unit
Collector-Emitter Voltage	V_{CEO}	35	45	Vdc
Collector-Base Voltage	V_{CBO}	45	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current − Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0) BC415 BC416	$V_{(BR)CEO}$	 35 45			Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0) BC415 BC416	$V_{(BR)CBO}$	 45 50			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	 5			Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = +125°C)	I_{CBO}			 15 5	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)	I_{EBO}			 15	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5 Vdc) BC415B/BC416B BC415C/BC416C (I_C = 2 mAdc, V_{CE} = 5 Vdc) BC415B/BC416B BC415C/BC416C BC415/BC416	h_{FE}	 100 100 180 380 120	 150 270 290 500 350	 460 800 800	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 10 mAdc, I_B = see note 1) (I_C = 100 mAdc, I_B = 5 mAdc, see note 2)	$V_{CE(sat)}$		 0.075 0.3 0.25	 0.25 0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5 mAdc)	$V_{BE(sat)}$		 1.1		Vdc
Base-Emitter On Voltage (I_C = 10 μAdc, V_{CE} = 5 Vdc) (I_C = 100 μAdc, V_{CE} = 5 Vdc) (I_C = 2 mAdc, V_{CE} = 5 Vdc)	$V_{BE(on)}$	 0.55	 0.52 0.55 0.62	 0.75	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	f_T		 250		MHz
Collector-Base Capacitance (V_{CE} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{cbo}		 2.5		pF

Note 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V

Note 2: Pulse test = 300 μs − Duty cycle = 2%

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Typ.	Max.	Unit
Input Impedance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC415B/BC416B BC415C/BC416C	h_{ie}	3.2 5.0	6.0 8.0	8.5 14.0	KΩ
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC415B/BC416B BC415C/BC416C	h_{re}		3.5 4.0		10^{-4}
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC415A BC415B/BC416B BC415C/BC416C	h_{fe}	125 240 450	200 330 600	260 500 900	
Output Admittance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BC415B/BC416B BC415C/BC416C	h_{oe}		10 12	60 110	μmhos
Noise Figure (I_C = 200 μAdc, V_{CE} = 5 Vdc, R_S = 2 KΩ, f = 30 Hz − 15 KHz)		NF		0.5	2.0	dB
Equivalent Input Noise Voltage (I_C = 200 μAdc, V_{CE} = 5 V, R_S = 2 kΩ, f = 120 Hz)		V_T		8.0	10	$nV/\sqrt{Hz}$
Equivalent Input Noise Voltage (I_C = 200 μAdc, V_{CE} = 5 V, R_S = 2 KΩ, f = 10 Hz − 50 Hz)		V_T		74	110	$nV/\sqrt{Hz}$

2

BC445
BC447
BC449

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPS8098 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 445	BC 447	BC 449	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current – Continuous	I_C	300			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0) BC445 BC447 BC449	$V_{(BR)CEO}$	 60 80 100	 — — —	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA, I_E = 0) BC445 BC447 BC449	$V_{(BR)CBO}$	 60 80 100	 — — —	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5	—	—	Vdc
Collector Cutoff Current V_{CB} = 30 Vdc – I_E = 0 BC445 V_{CB} = 40 Vdc – I_E = 0 BC447 V_{CB} = 60 Vdc – I_E = 0 BC449	I_{CBO}	 — — —	 — — —	 100 100 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain – I_C = 2 mA, V_{CE} = 5 V full range A BC445/447 only B I_C = 10 mA, V_{CE} = 5 V full range A BC445/447 only B I_C = 100 mA, V_{CE} = 5 V full range A BC445/447 only B	h_{FE}	50 120 180 50 100 160 50 60 90		460 220 460	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.1	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	—	0.85	—	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	0.8	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	3.0	—	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	16	—	pF

* Pulse test - Pulse width ≤ 300 μs - Duty Cycle 2%

BC446
BC448
BC450

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BC 446	BC 448	BC 450	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current – Continuous	I_C	300			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

Refer to MPS8598 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0) BC446 BC448 BC450	$V_{(BR)CEO}$	 60 80 100	 — — —	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA, I_E = 0) BC446 BC448 BC450	$V_{(BR)CBO}$	 60 80 100	 — — —	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	 4.0	 —	 —	Vdc
Collector Cutoff Current V_{CB} = 30 Vdc − I_E = 0 BC446 V_{CB} = 40 Vdc − I_E = 0 BC448 V_{CB} = 60 Vdc − I_E = 0 BC450	I_{CBO}	 — — —	 — — —	 100 100 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain − I_C = 2 mA, V_{CE} = 5 V full range A BC446/448 only B I_C = 10 mA, V_{CE} = 5 V full range A BC446/448 only B I_C = 100 mA, V_{CE} = 5 V full range A BC446/448 only B	h_{FE}	50 120 180 50 100 160 50 60 90		460 220 460	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 —	 0.125	 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 —	 0.85	 —	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	 —	 0.76	 1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	 100	 200	 —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	 —	 3.0	 —	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	 —	 20	 —	pF

* Pulse test - Pulse width ≤ 300 μs - Duty Cycle 2%

2

BC485
BC487
BC489

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH CURRENT TRANSISTORS

NPN SILICON

Refer to MPSA05 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 485	BC 487	BC 489	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	Vdc
Collector-Base Voltage	V_{CBO}	45	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current – Continuous	I_C	1.0			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0) BC485 BC487 BC489	$V_{(BR)CEO}$	45 60 80	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) BC485 BC487 BC489	$V_{(BR)CBO}$	45 60 80	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current V_{CB} = 30 Vdc – I_E = 0 BC485 V_{CB} = 40 Vdc – I_E = 0 BC487 V_{CB} = 60 Vdc – I_E = 0 BC489	I_{CBO}	— — —	— — —	100 100 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain (I_C = 10 mAdc – V_{CE} = 2.0 Vdc) (I_C = 100 mAdc – V_{CE} = 2.0 Vdc) full range – L – A – B (I_C = 1 Adc – V_{CE} = 5.0 Vdc)	h_{FE}	40 60 60 100 160 15	 120 160 260	 400 150 250 400	
Collector Emitter Saturation Voltage (I_C = 500 mAdc – I_B = 50 mAdc) (I_C = 1 Adc – I_B = 100 mAdc)	$V_{CE(sat)}$	— —	0.2 0.3	0.50 —	Vdc
Base Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc – I_B = 100 mAdc)	$V_{BE(sat)}$	—	0.85 0.90	1.20	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)	f_T	—	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	7	—	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	50	—	pF

* Pulse test - Pulse width = 300 μs - Duty Cycle 2%.

BC486
BC488
BC490

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH CURRENT TRANSISTORS

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BC 486	BC 488	BC 490	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	Vdc
Collector-Base Voltage	V_{CBO}	45	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0			Vdc
Collector Current – Continuous	I_C	1.0			Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

Refer to MPSA55 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* ($I_C = 10$ mAdc, $I_B = 0$)	BC486 BC488 BC490	$V_{(BR)CEO}$	45 60 80	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	BC486 BC488 BC490	$V_{(BR)CBO}$	45 60 80	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current $V_{CB} = 30$ Vdc – $I_E = 0$ $V_{CB} = 40$ Vdc – $I_E = 0$ $V_{CB} = 60$ Vdc – $I_E = 0$	 BC486 BC488 BC490	I_{CBO}	 — — —	 — — —	 100 100 100	nAdc
ON CHARACTERISTICS*						
DC Current Gain ($I_C = 10$ mAdc – $V_{CE} = 2.0$ Vdc) ($I_C = 100$ mAdc – $V_{CE} = 2.0$ Vdc)	 full range – L – A – B	h_{FE}	 40 60 60 100 160	 — 100 140 260	 400 150 250 400	
($I_C = 1$ Adc — $V_{CE} = 5.0$ Vdc)			15			
Collector Emitter Saturation Voltage ($I_C = 500$ mAdc – $I_B = 50$ mAdc) ($I_C = 1$ Adc – $I_B = 100$ mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.50	 0.50 —	Vdc
Base Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1$ Adc – $I_B = 100$ mAdc)		$V_{BE(sat)}$	 —	 0.90 1.00	 1.20	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain-Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 2.0$ Vdc, f = 100 MHz)		f_T	—	150	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{ob}	—	9	—	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ib}	—	110	—	pF

* Pulse test - Pulse width = 300 μs - Duty Cycle 2%.

2

BC517

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC517	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current − Continuous	I_C	140	mAdc
Total Power Dissipation $T_A = 25°C$ Derate above 25°C	P_D	625 12	mW mW/°C
Total Power Dissipation $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	10	—	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}			500	nAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 20 mAdc, V_{CE} = 2 Vdc)	h_{FE}	30 000			—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$			1	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$			1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain−Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	125	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	5.0	8.0	pF

(1) Pulse Test Pulse Width ≤ 2.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$

BC546
BC547
BC548

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BC 546	BC 547	BC 548	Unit
Collector-Emitter Voltage	V_{CEO}	65	45	30	Vdc
Collector-Base Voltage	V_{CBO}	80	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1 mA, I_B = 0)	BC546 BC547 BC548	$V_{(BR)CEO}$	65 45 30			V
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	BC546 BC547 BC548	$V_{(BR)EBO}$	6 6 6			V
Collector Cutoff Current (V_{CE} = 70 V, V_{BE} = 0) (V_{CE} = 50 V, V_{BE} = 0) (V_{CE} = 35 V, V_{BE} = 0) (V_{CE} = 30 V, T_A = 125°C)	BC546 BC547 BC548 BC546 BC547 BC548	I_{CES}		0.20 0.20 0.20	15 15 15 4 4 4	nA μA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μA, V_{CE} = 5 V)	BC546A/547A/548A BC436B/547B/548B BC548C	h_{FE}		90 150 270		
(I_C = 2 mA, V_{CE} = 5 V)	BC546 BC547 BC548 BC546A/547A/548A BC546B/547B/548B BC548C		125 110 110 110 200 420	 180 290 520	500 800 800 220 450 800	
(I_C = 100 mA, V_{CE} = 5 V)	BC546A/547A/548A BC546B/547B/548B BC548C			120 180 300		
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5 mA) (I_C = 10 mA, I_B = See Note 1)		$V_{CE(sat)}$		0.09 0.2 0.3	0.25 0.60 0.6	V
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA)		$V_{BE(sat)}$		0.7		V
Base-Emitter On Voltage (I_C = 2 mA, V_{CE} = 5 V) (I_C = 10 mA, V_{CE} = 5 V)		$V_{BE(on)}$	0.55		0.70 0.77	V

NOTE 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V.

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ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 5 V, f = 100 MHz)	BC546 BC547 BC548	f_T	150 150 150	300 300 300		MHz
Output Capacitance (V_{CB} = 10 V, I_C = 0, f = 1 MHz)		C_{obo}		1.7	4.5	pF
Input Capacitance (V_{BE} = 0.5 V, I_C = 0, f = 1 MHz)		C_{ibo}		10		pF
Input Impedance (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC546A/547A/548A BC546B/547B/548B BC548C	h_{ie}	1.6 3.2 6.0	2.7 4.5 8.7	4.5 8.5 15.0	KΩ
Voltage Feedback Ratio (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC546A/547A/548A BC546B/547B/548B BC548C	h_{re}		1.5 2.0 3.0		$X10^{-4}$
Small-Signal Current Gain (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC546A/547A/548A BC546B/547B/548B BC548C	h_{fe}	125 240 450	220 330 600	260 500 900	
Output Admittance (I_C = 2 mA, V_{CE} = 5 V, f = 1 KHz)	BC546A/547A/548A BC546B/547B/548B BC548C	h_{oe}		8 10 12	25 35 50	μmhos
Noise Figure (I_C = 0.2 mA, V_{CE} = 5 V, R_S = 2 KOhms, f = 1 KHz, Δf = 200 Hz)	BC546 BC547 BC548	NF		2 2 2	10 10 10	dB

BC547/BC548

FIGURE 1 – NORMALIZED DC CURRENT GAIN

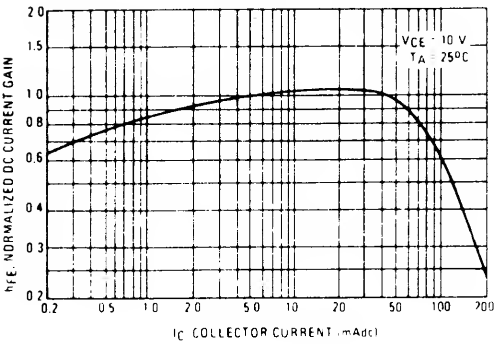


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

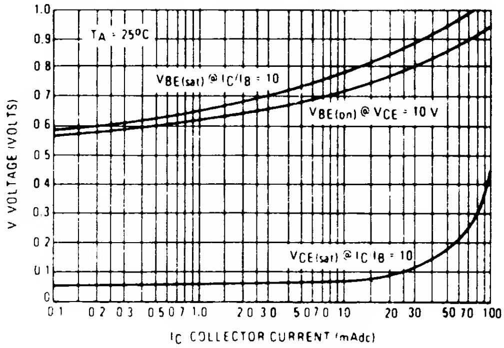


FIGURE 3 – COLLECTOR SATURATION REGION

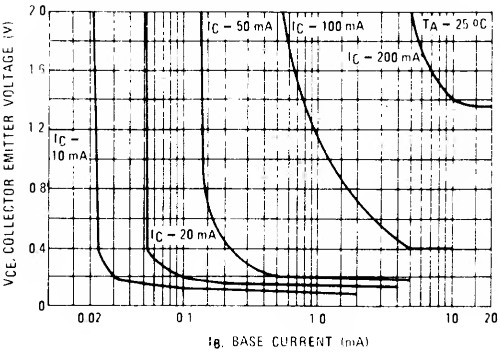


FIGURE 4 – BASE EMITTER TEMPERATURE COEFFICIENT

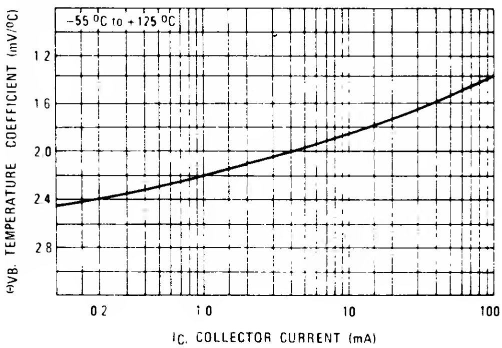


FIGURE 5 – CAPACITANCES

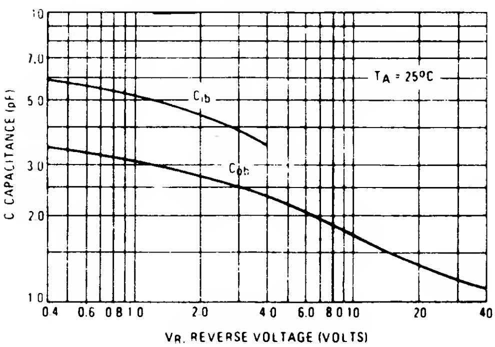
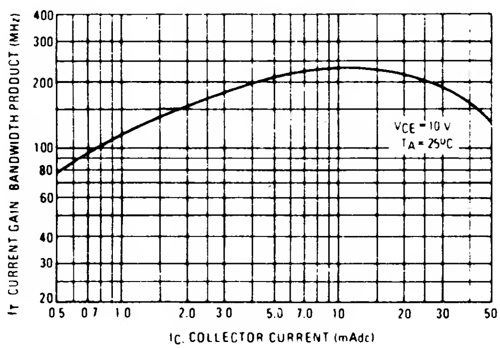


FIGURE 6 – CURRENT GAIN–BANDWIDTH PRODUCT



BC546

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FIGURE 7 – DC CURRENT GAIN

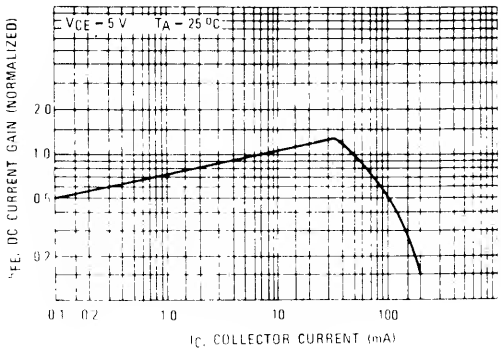


FIGURE 8 – "ON" VOLTAGE

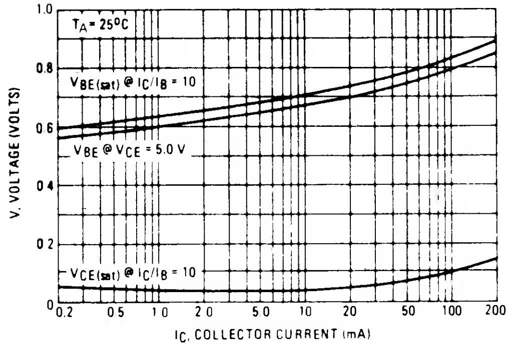


FIGURE 9 – COLLECTOR SATURATION REGION

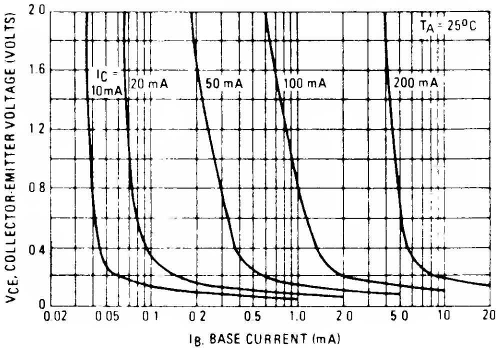


FIGURE 10 – BASE EMITTER TEMPERATURE COEFFICIENT

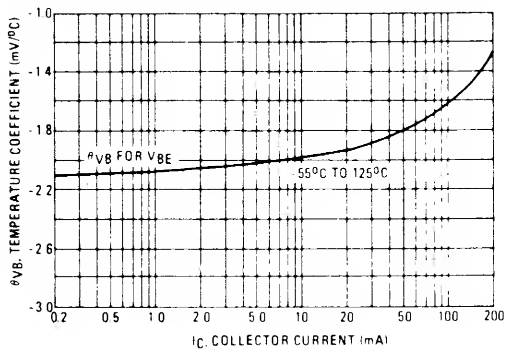


FIGURE 11 – CAPACITANCE

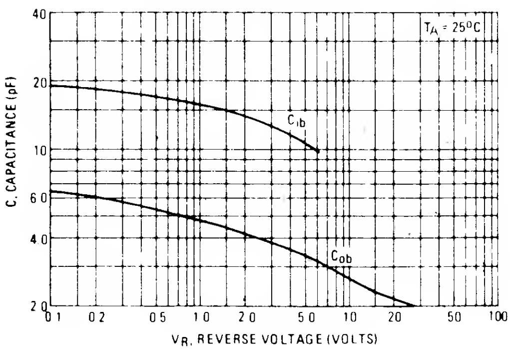
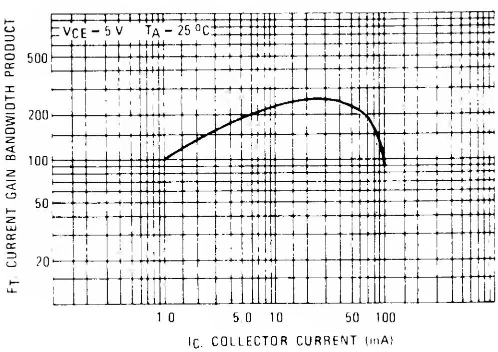


FIGURE 12 – CURRENT GAIN–BANDWIDTH PRODUCT



BC549
BC550

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

LOW NOISE TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 549	BC 550	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	Vdc
Collector-Base Voltage	V_{CBO}	30	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$) BC549 BC550	$V_{(BR)CEO}$	 30 45			Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$) BC549 BC550	$V_{(BR)CBO}$	 30 50			Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5			Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = +125°C$)	I_{CBO}			 15 5	 nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 4$ Vdc, $I_C = 0$)	I_{EBO}			15	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10\ \mu$Adc, $V_{CE} = 5$ Vdc) BC549B/550B BC549C/550C ($I_C = 2$ mAdc, $V_{CE} = 5$ Vdc) BC549A BC549B/550B BC549C/550C BC549/550	h_{FE}	 100 100 110 200 420 110	 150 270 290 500 	 220 450 800 800	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc) ($I_C = 10$ mAdc, I_B = see note 1) ($I_C = 100$ mAdc, $I_B = 5$ mAdc, see note 2)	$V_{CE(sat)}$		 0.075 0.3 0.25	 0.25 0.6 0 6	Vdc
Base-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 5$ mAdc)	$V_{BE(sat)}$		1.1		Vdc
Base-Emitter On Voltage ($I_C = 10\ \mu$Adc, $V_{CE} = 5$ Vdc) ($I_C = 100\ \mu$Adc, $V_{CE} = 5$ Vdc) ($I_C = 2$ mAdc, $V_{CE} = 5$ Vdc)	$V_{BE(on)}$	 0.55	 0.52 0.55 0.62	 0.75	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain-Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 5$ Vdc, f = 100 MHz)	f_T		250		MHz
Collector-Base Capacitance ($V_{CE} = 10$ Vdc, $I_E = 0$, f = 1 MHz)	C_{cbo}		2.5		pF

Note 1: I_B is value for which $I_C = 11$ mA at $V_{CE} = 1$ V

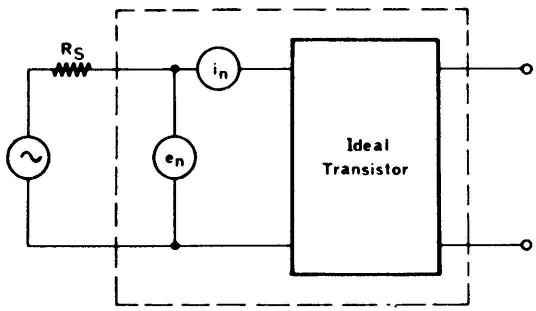
Note 2: Pulse test = 300 μs − Duty cycle = 2%

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Typ.	Max.	Unit
Input Impedance (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz)	BC549B/BC550B	h_{ie}	3.2	6.0	8.5	KΩ
	BC549C/BC550C		6.0	8.7	15.0	
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz)	BC549B/BC559B	h_{re}		2		10^{-4}
	BC549C/BC550C			3		
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz)	BC549B/BC550B	h_{fe}	240	330	500	
	BC549C/BC550C		450	600	900	
Output Admittance (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz)	BC549B/BC550B	h_{oe}		10	60	μmhos
	BC549C/BC550C			12	110	
Noise Figure (I_C = 200 μAdc, V_{CE} = 5 Vdc, R_S = 2 KΩ, f = 30 Hz − 15 KHz)		NF		0.6	2.5	dB
Equivalent Input Noise Voltage (I_C = 200 μAdc, V_{CE} = 5 V, R_S = 2 kΩ, f = 120 Hz) See Application note, Section I		V_T		8.0	12	nV/$\sqrt{Hz}$
Equivalent Input Noise Voltage (I_C = 200 μAdc, V_{CE} = 5 V, R_S = 2 KΩ, f = 10 Hz − 50 Hz) See Application note, Section II		V_T		74	135	nV/$\sqrt{Hz}$

FIGURE 1 — TRANSISTOR NOISE MODEL



NOISE APPLICATION NOTE

I. NOISE FIGURE RELATED TO V_T, e_n, and i_n

For a transistor, total noise at the input may be expressed as:

$$V_T = \left[e_n^2 + 4\ KT\ R_S + i_n^2\ R_S^2\right]^{1/2} \qquad (1)$$

Where:

V_T = total noise voltage at the transistor input (Volts/$\sqrt{\text{Hz}}$)

e_n = noise voltage of the transistor referred to the input (figures 2 & 3)

i_n = noise current of the transistor referred to the input (figure 4)

K = Boltzmann's constant (1.38×10^{-23} j/°K)

T = Temperature of the source resistance (°K)

R_S = Source resistance (Ohms)

Example:
Find the total noise at the input of a BC550 for a collector current of 1mA and a source impedance of 1KΩ at a frequency of 120 Hz and a temperature of 25 °C.

1. V_T is calculated from e_n, i_n
Read e_n 4.5 nV/$\sqrt{\text{Hz}}$ from figure 3 (Note that this is for a one cycle bandwidth)
Read i_n 5.8 pA/$\sqrt{\text{Hz}}$ from figure 4

$$V_T = [(3.5 \times 10^{-9})^2 + (4).(1.38 \times 10^{-23}).(300).(1 \times 10^3) + (5.8 \times 10^{-12})^2.(1 \times 10^3)^2]^{1/2}$$

Thus: $\boxed{V_T = 8.2\ \text{nV}}$.

This checks with the value of 8 nV shown in figure 6.

2. Noise figure is calculated from V_T
Noise figure is defined as:

$$NF = 20 \log_{10} \frac{\text{total noise voltage}}{\text{noise voltage contributed by source resistance}}$$

or

$$NF = 20 \log_{10} \left[\frac{V_T^2}{4\ KT\ R_S}\right]^{1/2}$$

Noise figure can be calculated for the above example as follows:

$$NF = 20 \log_{10} \left[\frac{(8 \times 10^{-9})^2}{16.6 \times 10^{-18}}\right]^{1/2}$$

Thus: $\boxed{NF = 5.9\ \text{dB}}$

This checks with the values of 6 dB read from figure 7.

To minimize noise in a transistor stage, one might use figure is minimum. This is not necessarily true as shown by figure 6 where the total noise voltage is a minimum at small values of source impedance.
This can be seen from equation (1) which shows that total noise is a direct function of source resistance.

II. NOISE VARIATION WITH FREQUENCY

Noise over a frequency band can be handled in one of two ways depending upon whether total transistor noise is constant or variable over the bandwidth of interest:

1. For constant transistor noise, multiply, V_T by the square root of bandwidth. i.e., $V_T = V_T . f.^{1/2}$
2. For variable transistor noise integrate the spectral density V_T (where Δf = 1 Hz), over the bandwidth of interest.

Example: Low Frequency Noise
Find the total noise at the input in the bandwidth f_1 = 10 Hz, f_2 = 50 Hz at I_C = 200 µA and R_S = 2 KΩ
This example corresponds to the popular "FLICKER NOISE" test shown on many data sheets.

$$V_T^2 = \int_{-\infty}^{+\infty} V_T(f) \times [G(f)^2\ df$$

$(f_1 - f_2)$

where:

$$V^2_{T(f)} = e^2_{n(f)} + 4\ KT\ R_S + i^2_{n(f)}\ R^2_S$$

$e_{n(f)}$ and 4 KT R_S are constant in the bandwidth

$$i_{n(f)} = \frac{i_n^2\ (1\ \text{Hz})}{f} \qquad \text{(1/f noise spectrum density)}$$

G(f) bandpass filter
= 1 for $f \in (f_1, f_2)$
= 0 for $f \notin (f_1, f_2)$

after integration:

$$V^2_{T(f_1-f_2)} = (e^2_{n(f1)} + 4\ KT\ R_S) \times (f_2 - f_1) + R^2_S\ i^2_{n(f1)} \times f1 \times i_{n(f1)}{}^{f2}_{f1}$$

Now:
e_n = 5 nV/$\sqrt{\text{Hz}}$ at 10 Hz (from figure 2)
i_n = 7 pA/$\sqrt{\text{Hz}}$ at 10 Hz (from figure 4)

$$V_T^2\ (10\ \text{Hz}-50\ \text{Hz}) = [(25 + 33.1)\ 40 + 196 \times 10 \times 1.6].10^{-18}$$

Thus: $\boxed{V_T(10\ \text{Hz}-50\ \text{Hz}) = 74\ \text{nV}}$

2

FIGURE 2 – NOISE VOLTAGE vs FREQUENCY

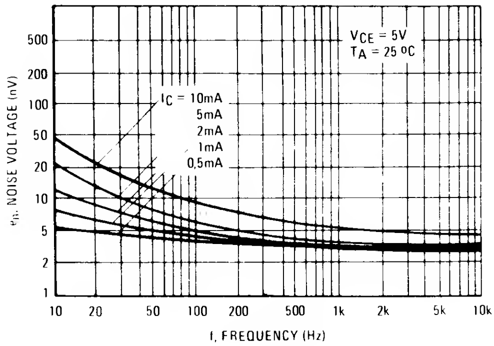


FIGURE 3 – NOISE VOLTAGE vs COLLECTOR CURRENT

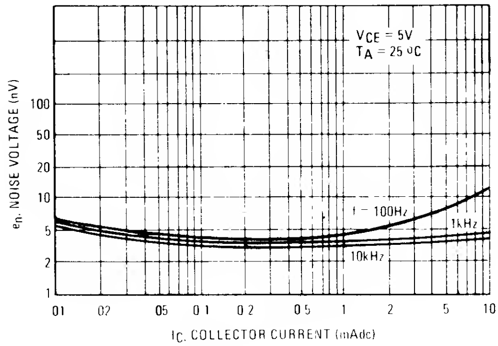


FIGURE 4 – NOISE CURRENT

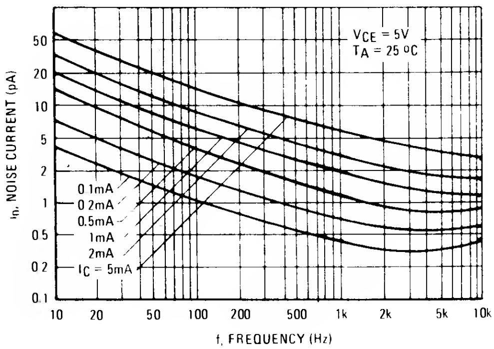


FIGURE 5 – WIDEBAND NOISE FIGURE

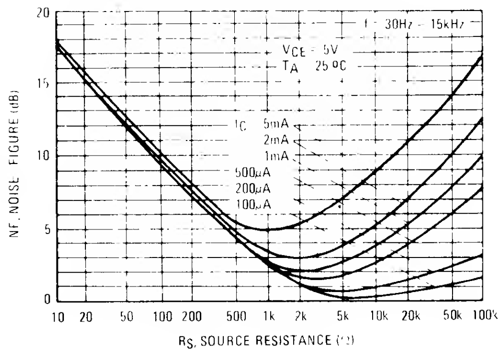


FIGURE 6 – TOTAL NOISE VOLTAGE (120 Hz)

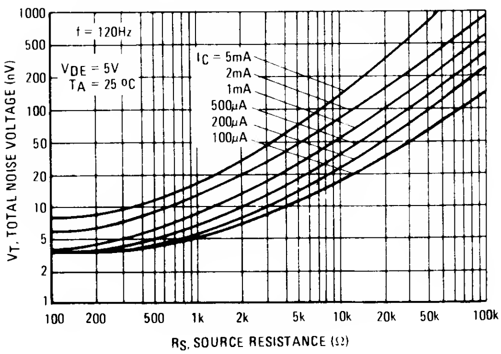


FIGURE 7 – NOISE FIGURE (120 Hz)

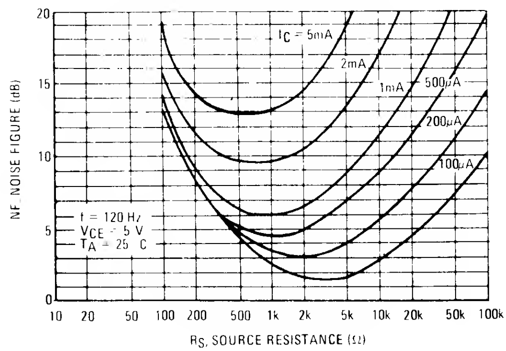


FIGURE 8 — NORMALIZED DC CURRENT GAIN

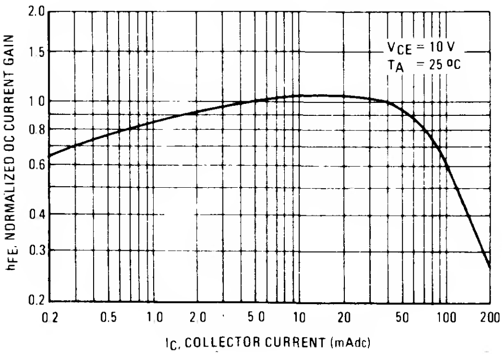


FIGURE 9 — "SATURATION" AND "ON" VOLTAGES

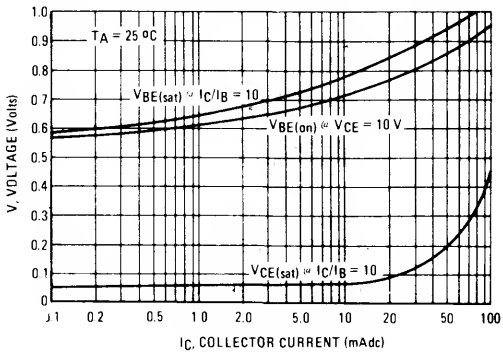


FIGURE 10 — CURRENT GAIN-BANDWIDTH PRODUCT

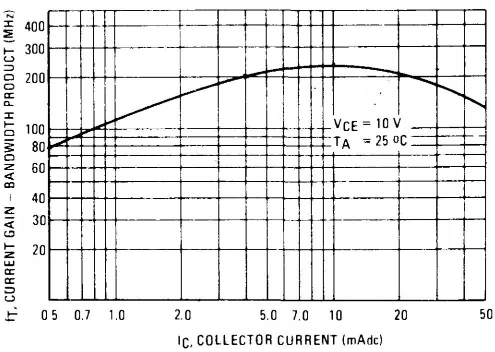


FIGURE 11 — CAPACITANCE

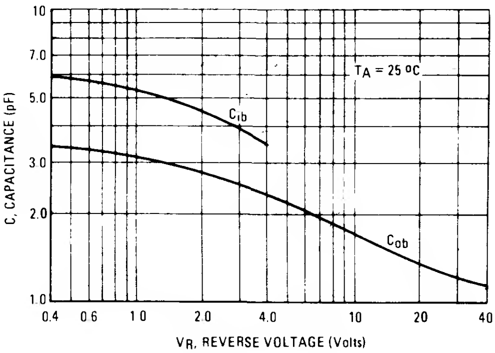


FIGURE 12 — OUTPUT ADMITTANCE

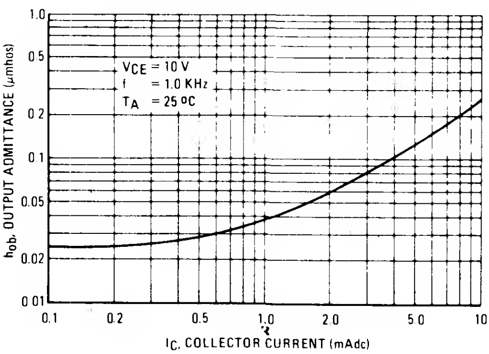
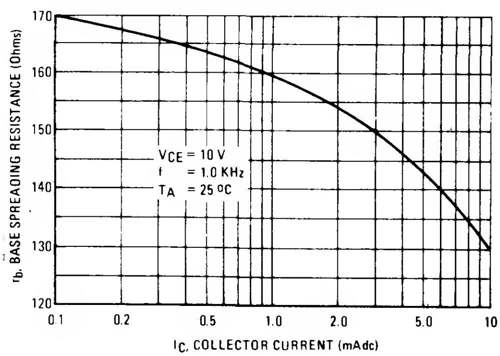


FIGURE 13 — BASE SPREADING RESISTANCE



2

BC556
BC557
BC558

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 556	BC 557	BC 558	Unit
Collector-Emitter Voltage	V_{CEO}	65	45	30	Vdc
Collector-Base Voltage	V_{CBO}	70	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current − Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	BC556 BC557 BC558	$V_{(BR)CEO}$	65 45 30	— — —	— — —	V
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BC556 BC557 BC558	$V_{(BR)EBO}$	5 5 5	— — —	— — —	V
Collector-Emitter Leakage Current (V_{CES} = 40 V) (V_{CES} = 20 V)	BC556 BC557 BC558	I_{CES}		2 2 2	100 100 100	nA
(V_{CES} = 20 V, T_A = 125°C)	BC556 BC557 BC558				4 4 4	μA
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5 V)	BC556A/557A/558A BC556B/557B/558B BC557C/558C	h_{FE}		90 150 270		
(I_C = 2 mAdc, V_{CE} = 5 V)	BC556 BC557 BC558 BC556A/557A/558A BC556B/557B/558B BC557C/558C		125 110 110 120 180 420	— — — 170 290 500	500 800 800 220 460 800	
(I_C = 100 mAdc, V_{CE} = 5 V)	BC556A/557A/558A BC556B/557B/558B BC557C/558C			120 180 300		
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 10 mAdc, I_B = see Note 1) (I_C = 100 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$	— — —	0.075 0.30 0.25	0.3 0.60 0.65	V
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mA) (I_C = 100 mAdc, I_B = 5 mA)		$V_{BE(sat)}$	— —	0.70 1.00	— —	V
Base-Emitter on Voltage (I_C = 2 mAdc, V_{CE} = 5 V) (I_C = 10 mA, V_{CE} = 5 V)		$V_{BE(on)}$	0.55	0.62 0.7	0.70 0.82	V

NOTE 1: I_C = 10 mAdc on the constant base current characteristic, which yields the point I_C = 11 mAdc, V_{CE} = 1 V.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 5 V, f = 50 MHz)	BC556 BC557 BC558	f_T		280 320 360		MHz
Output Capacitance (V_{CB} = 10 V, I_C = 0, f = 1 MHz)		C_{ob}		3	6.0	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5 V, R_S = 2 Kohms, f = 1 KHz, Δf = 200 Hz)	BC556 BC557 BC558	NF		2 2 2	10 10 10	dB
Input Impedance (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz)	BC556A/557A/558A BC556B/557B/558B BC557C/55BC	h_{ie}	1.2 3.0 5.0	2.7 4.5 8.0	4.5 8.0 14.0	kΩ
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz)	BC556A/557A/558A BC556B/557B/558B BC557C/558C	h_{re}		3.0 3.5 4.0		10^{-4}
Small-Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz)	BC556A/557A/558A BC556B/557B/55BB BC557C/55BC	h_{fe}	125 240 450	220 330 600	260 500 900	
Output Admittance (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz)	BC556A/557A/558A BC556B/557B/558B BC557C/55BC	h_{oe}		25 30 60	50 70 110	μmhos

BC557/BC558

2

FIGURE 1 – NORMALIZED DC CURRENT GAIN

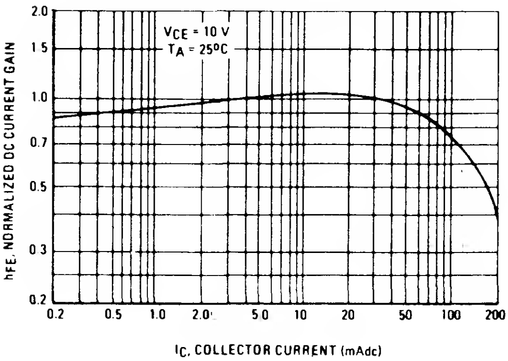


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

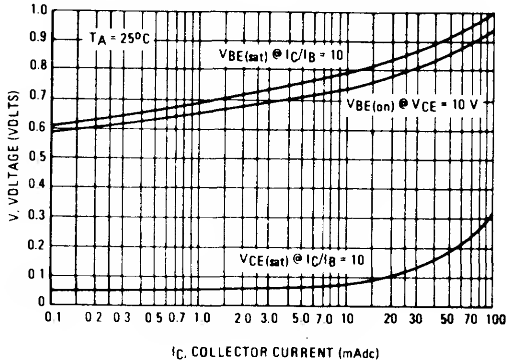


FIGURE 3 – COLLECTOR SATURATION REGION

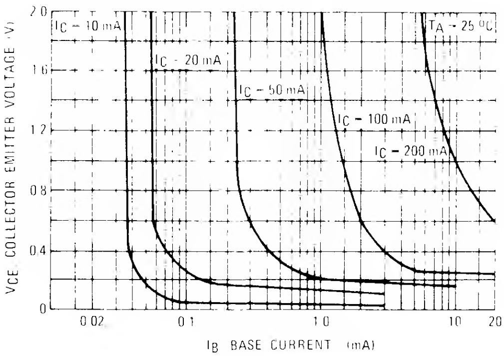


FIGURE 4 – BASE EMITTER TEMPERATURE COEFFICIENT

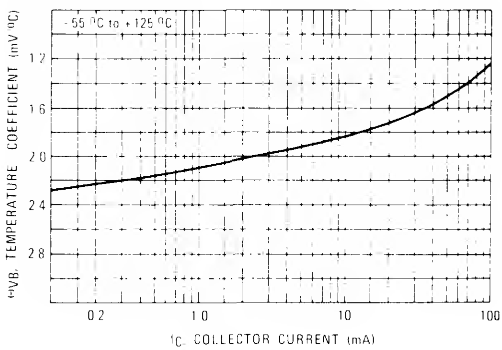


FIGURE 5 – CAPACITANCES

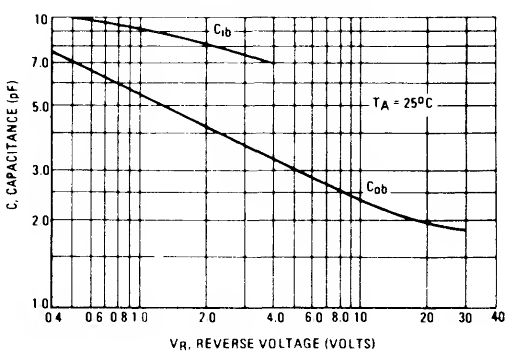
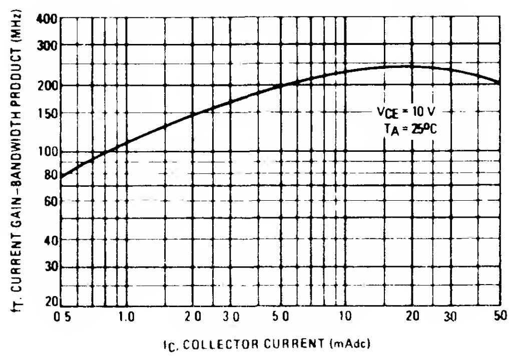


FIGURE 6 – CURRENT GAIN–BANDWIDTH PRODUCT



BC556

FIGURE 7 – DC CURRENT GAIN

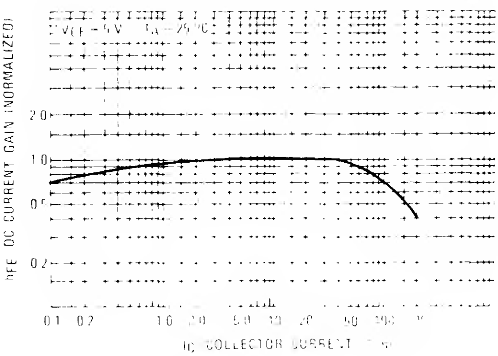


FIGURE 8 – "ON" VOLTAGE

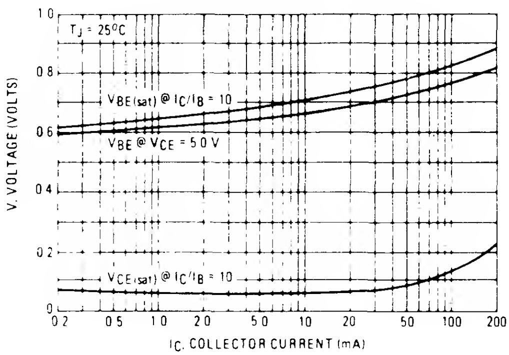


FIGURE 9 – COLLECTOR SATURATION REGION

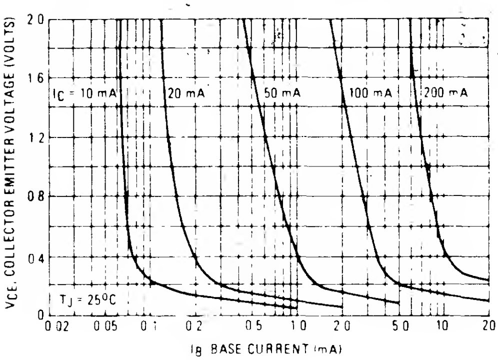


FIGURE 10 – BASE EMITTER TEMPERATURE COEFFICIENT

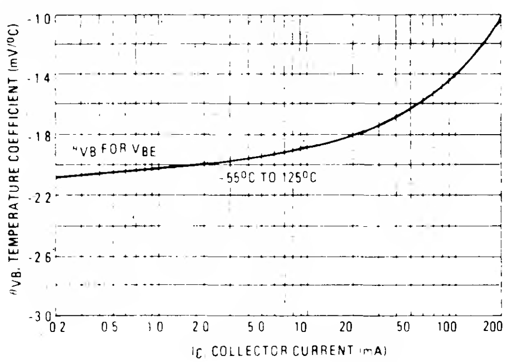


FIGURE 11 – CAPACITANCE

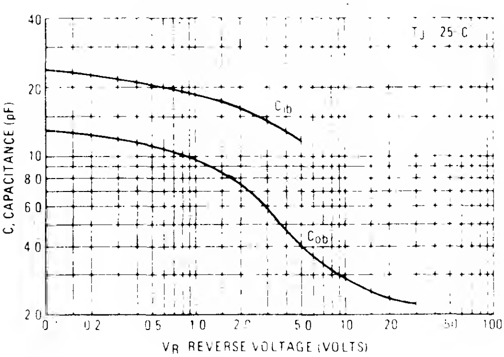


FIGURE 12 – CURRENT GAIN–BANDWIDTH PRODUCT

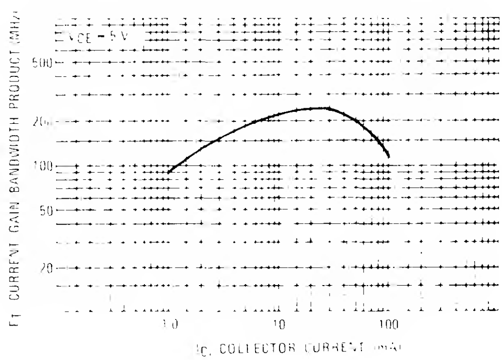


FIGURE 13 – THERMAL RESPONSE

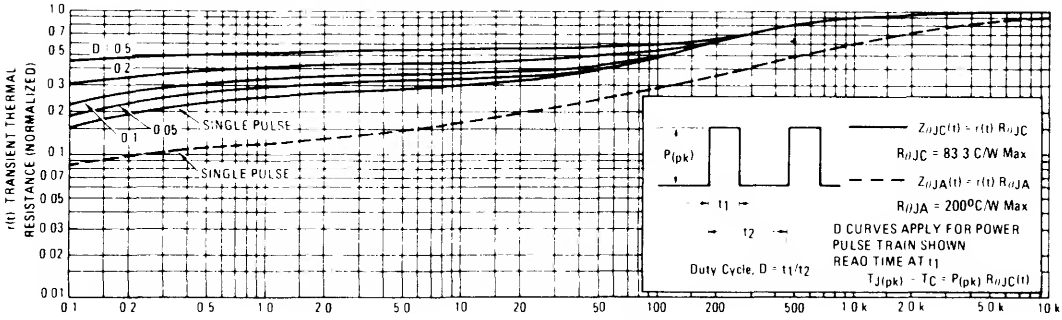
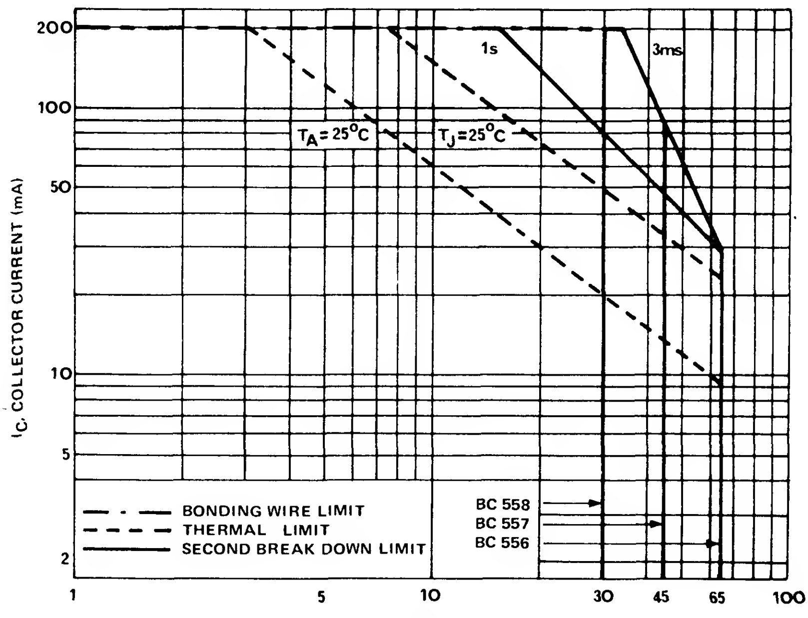


FIGURE 14 – ACTIVE REGION SAFE OPERATING AREA



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 14 is based upon $T_{J(pk)}$=150°C; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150$°C. $T_{J(pk)}$ may be calculated from the data of Figure 13. At high case or ambient temperatures thermal limitations will reduce the power that can be handled to values less than the limitations imposed by the secondary breakdown. (see AN 415).

BC559
BC560

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

LOW NOISE TRANSISTORS

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BC 559	BC 560	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	Vdc
Collector-Base Voltage	V_{CBO}	30	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current − Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0) BC559 BC560	$V_{(BR)CEO}$	 30 45			Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0) BC559 BC560	$V_{(BR)CBO}$	 30 50			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	$V_{(BR)EBO}$	 5			Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = + 125°C)	I_{CBO}			 15 5	 nAdc µAdc
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)	I_{EBO}			 15	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 µAdc, V_{CE} = 5 Vdc) BC559B/560B BC559C/560C (I_C = 2 mAdc, V_{CE} = 5 Vdc) BC559B/560B BC559C/560C BC559/560	h_{FE}	 100 100 180 380 120	 150 270 290 500	 460 800 800	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 10 mAdc, I_B = see note 1) (I_C = 100 mAdc, I_B = 5 mAdc, see note 2)	$V_{CE(sat)}$		 0.075 0.3 0.25	 0.25 0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5 mAdc)	$V_{BE(sat)}$		 1.1		Vdc
Base-Emitter On Voltage (I_C = 10 µAdc, V_{CE} = 5 Vdc) (I_C = 100 µAdc, V_{CE} = 5 Vdc) (I_C = 2 mAdc, V_{CE} = 5 Vdc)	$V_{BE(on)}$	 0.55	 0.52 0.55 0.62	 0.75	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	f_T		 250		MHz
Collector-Base Capacitance (V_{CE} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{cbo}		 2.5		pF

Note 1: I_B is value for which I_C = 11 mA at V_{CE} = 1 V

Note 2: Pulse test = 300 µs − Duty cycle = 2%

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
Input Impedance (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz) BC559B/BC560B	h_{ie}	3.2	6.0	8.5	KΩ
BC559C/BC560C		5.0	8.0	14.0	
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz) BC559B/BC560B	h_{re}		3.5		10^{-4}
BC559C/BC560C			4.0		
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz) BC559B/BC560B	h_{fe}	240	330	500	
BC559C/BC560C		450	600	900	
Output Admittance (I_C = 2 mAdc, V_{CE} = 5 V, f = 1 KHz) BC559B/BC560B	h_{oe}		10	60	μmhos
BC559C/BC560C			12	110	
Noise Figure (I_C = 200 μAdc, V_{CE} = 5 Vdc, R_S = 2 KΩ, f = 30 Hz − 15 KHz)	NF		0.5	2.0	dB
Equivalent Input Noise Voltage (I_C = 200 μAdc, V_{CE} = 5 V, R_S = 2 kΩ, f = 120 Hz) See Application note, Section I	V_T		8.0	10	nV/$\sqrt{Hz}$
Equivalent Input Noise Voltage (I_C = 200 μAdc, V_{CE} = 5 V, R_S = 2 KΩ, f = 10 Hz − 50 Hz) See Application note, Section II	V_T		74	110	nV/$\sqrt{Hz}$

FIGURE 1 – NOISE VOLTAGE V_S FREQUENCY

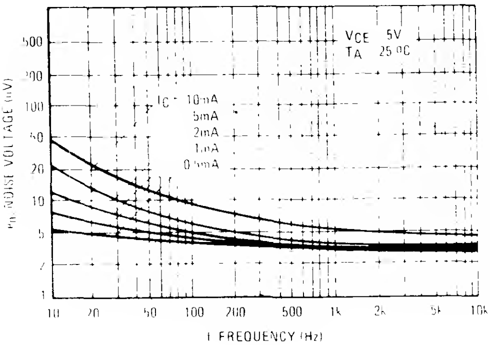


FIGURE 2 – NOISE VOLTAGE V_S COLLECTOR CURRENT

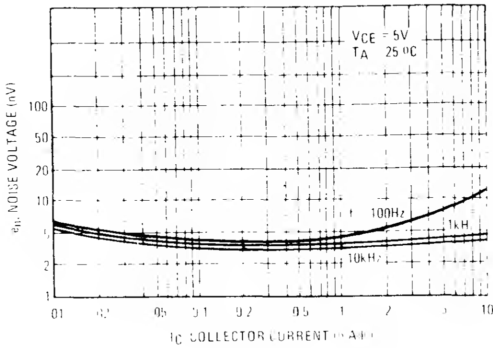


FIGURE 3 – NOISE CURRENT

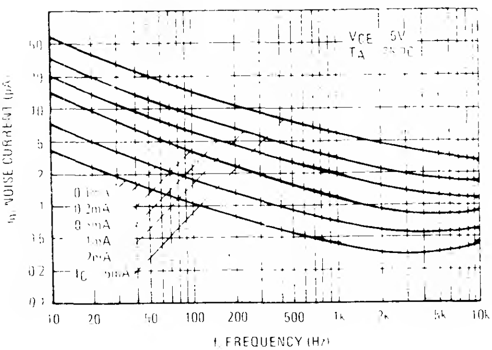


FIGURE 4 – WIDEBAND NOISE FIGURE

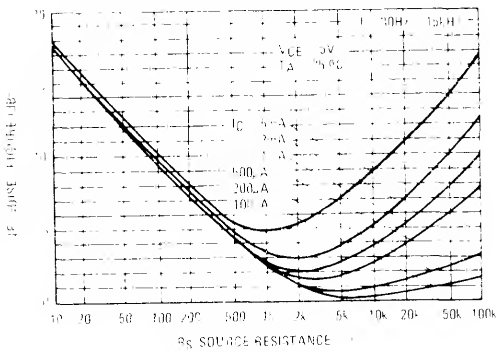


FIGURE 5 – TOTAL NOISE VOLTAGE (120 Hz)

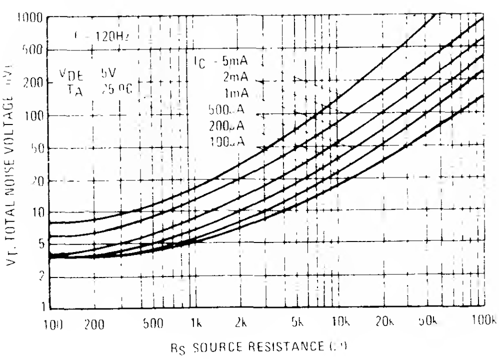


FIGURE 6 – NOISE FIGURE (120 Hz)

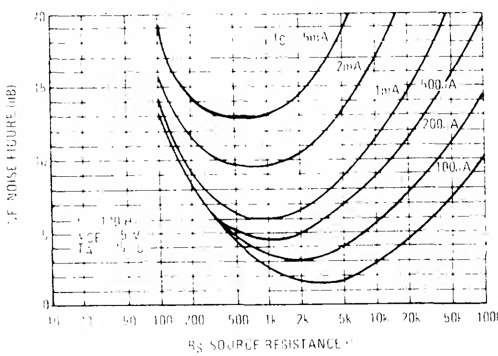


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FIGURE 7 – NORMALIZED DC CURRENT GAIN

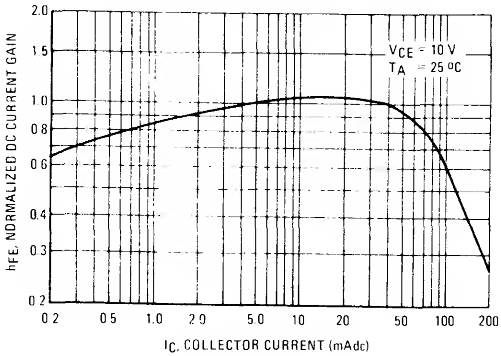


FIGURE 8 – "SATURATION" AND "ON" VOLTAGES

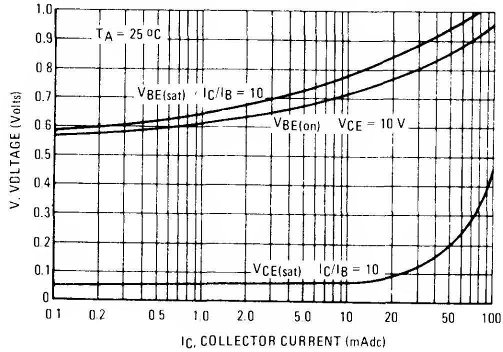


FIGURE 9 – CURRENT GAIN-BANDWIDTH PRODUCT

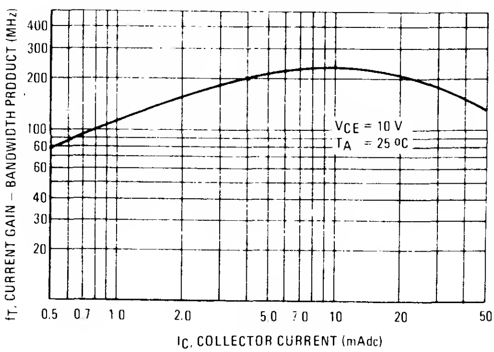


FIGURE 10 – CAPACITANCE

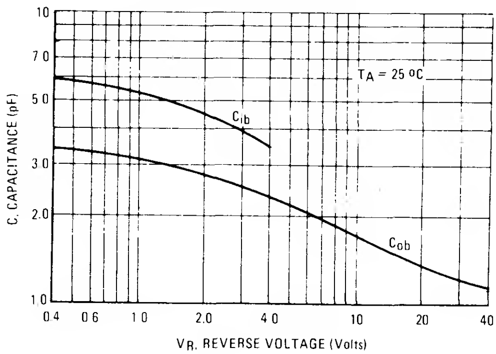


FIGURE 11 – OUTPUT ADMITTANCE

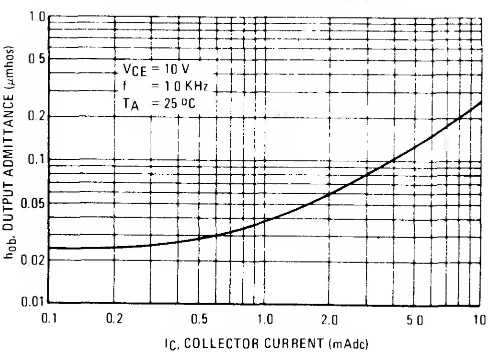
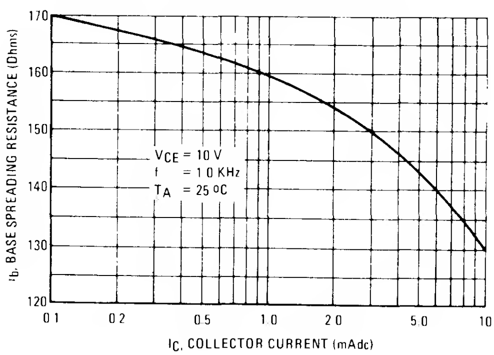


FIGURE 12 – BASE SPREADING RESISTANCE



BC585 (NPN)
BC586 (PNP)

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

SILICON TEMPERATURE SENSORS

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	BV_{CEO}	20			Vdc
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)	BV_{CBO}	25			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	BV_{EBO}	5			Vdc
Collector Cutoff Current (V_{CB} = 15 V, I_E = 0)	I_{CBO}			100	nAdc
Emitter Cutoff Current (V_{EB} = 4 V, I_C = 0)	I_{EBO}			100	nAdc
DC Current Gain (I_C = 0.5 mA, V_{CE} = 5 V)	h_{FE}	120		320	
Base-Emitter On Voltage (I_C = 0.5 mA, V_{CE} = 5 V)	$V_{BE(on)}$	0.57		0.69	Vdc
Thermal Time Constant in Oil Bath	τ		10		sec

BC585 (NPN), BC586 (PNP)

FIGURE 1 – TYPICAL APPLICATION BC 585

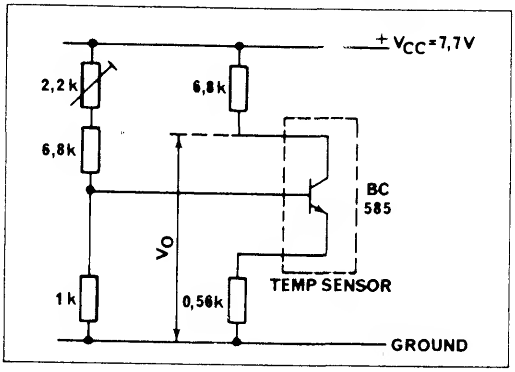


FIGURE 2 – OUTPUT VOLTAGE VERSUS TEMPERATURE

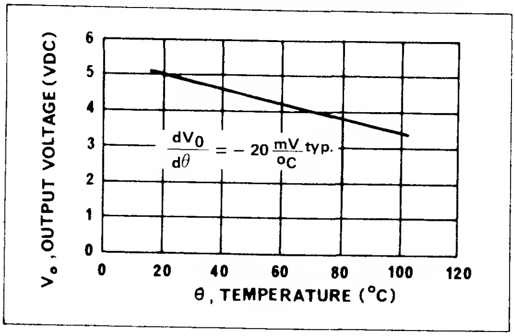


FIGURE 3 – TYP. ERROR DISTRIBUTION OF TEMP. COEF.

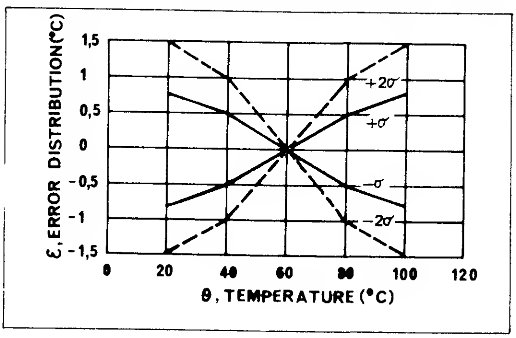


FIGURE 4 – TYPICAL APPLICATION BC 586

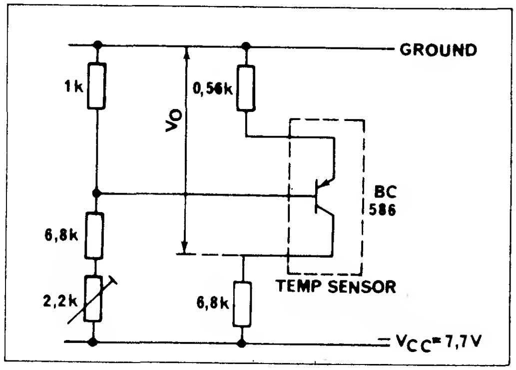


FIGURE 5 – OUTPUT VOLTAGE VERSUS TEMPERATURE

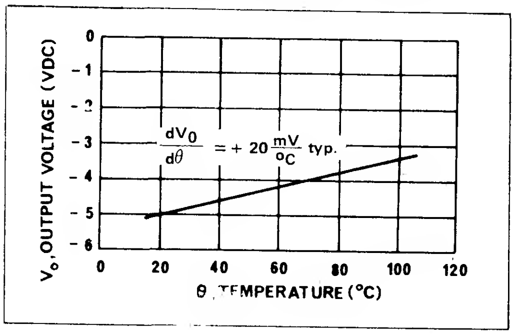
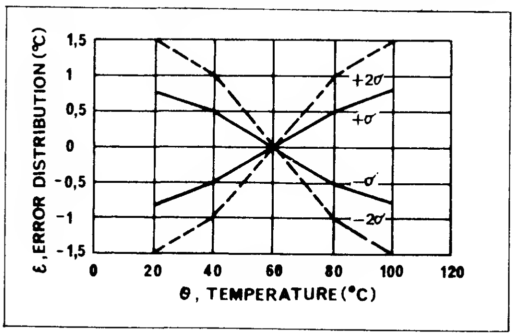


FIGURE 6 – TYP. ERROR DISTRIBUTION OF TEMP. COEF.



Note

These devices are mainly intended for use in temperature control applications using the following linear integrated circuits:

UAA 1004 }
UAA 1005 } zero voltage switch for on-off controls;

UAA 1006 zero voltage switch for proportional controls.

2

BC617
BC618

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

DARLINGTON TRANSISTORS

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 617	BC 618	Unit
Collector-Emitter Voltage	V_{CEO}	40	55	Vdc
Collector-Base Voltage	V_{CBO}	50	80	Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $V_{BE} = 0$)	BC617 BC618	$V_{(BR)CEO}$	40 55	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	BC617 BC618	$V_{(BR)CBO}$	50 80	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	Both Types	$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 40$ Vdc, $V_{BE} = 0$) ($V_{CE} = 60$ Vdc, $V_{BE} = 0$)	BC617 BC618	I_{CES}	— —	— —	50 50	nAdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$)	BC617 BC618	I_{CBO}	— —	— —	50 50	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)	Both Types	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
Collector-Emitter Saturation Voltage ($I_C = 200$ mA) ($I_B = 0.2$ mA)	Both Types	$V_{CE(sat)}$			1.1	V
Base-Emitter Saturation Voltage ($I_C = 200$ mA) ($I_B = 0.2$ mA)	Both Types	$V_{BE(sat)}$			1.6	V
Current Gain ($I_C = 100$ μA, $V_{CE} = 5$ V) ($I_C = 10$ mA, $V_{CE} = 5$ V) ($I_C = 200$ mA, $V_{CE} = 5$ V) ($I_C = 1$ A, $V_{CE} = 5$ V)	BC617 BC618 BC617 BC618 BC617 BC618 BC617 BC618	h_{FE}	4000 2000 10000 4000 20000 10000 10000 4000		 70000 50000	
DYNAMIC CHARACTERISTICS						
Current gain – Bandwidth product ($I_C = 500$ mA, $V_{CE} = 5$ V) ($f = 100$ MHz)	Both Types	f_T	150			MHz
Output Capacitance ($V_{CB} = 10$ V, $I_E = 0$, $f = 1$ MHz)		C_{ob}			4.5	pF

2

BC635
BC637
BC639

CASE 29-02, STYLE 14
TO-92 (TO-226AA)

HIGH CURRENT TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 635	BC 637	BC 639	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	Vdc
Collector-Base Voltage	V_{CBO}	45	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current – Continuous	I_C	1.0			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 6.4			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.75 22			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	45	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	156	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage*	$V_{(BR)CEO}$				Vdc
(I_C = 10 mAdc, I_B = 0) BC635		45	—	—	
BC637		60	—	—	
BC639		80	—	—	
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$				Vdc
(I_C = 100 μAdc, I_E = 0) BC635		45	—	—	
BC637		60	—	—	
BC639		80	—	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				nAdc
V_{CB} = 30 Vdc – I_E = 0 BC635		—	—	100	
V_{CB} = 30 Vdc – I_E = 0 BC637		—	—	100	
V_{CB} = 30 Vdc – I_E = 0 BC639		—	—	100	
ON CHARACTERISTICS*					
DC Current Gain	h_{FE}				
(I_C = 5 mAdc, V_{CE} = 2.0 Vdc)		25	—	—	
(I_C = 150 mAdc, V_{CE} = 2.0 Vdc)					
BC635		40	—	250	
BC637		40	—	160	
BC639		40	—	160	
(I_C = 500 mA, V_{CE} = 2 V)		25	—	—	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—		0.50	Vdc
Base-Emitter on Voltage (I_C = 500 mAdc, V_{CE} = 2 Vdc)	$V_{BE(on)}$	—		1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)	f_T	—	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	7	—	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	50	—	pF

*Pulse test - Pulse width ≤ 300 μs - Duty Cycle 2%

FIG. 1 — ACTIVE REGION SAFE OPERATING AREA

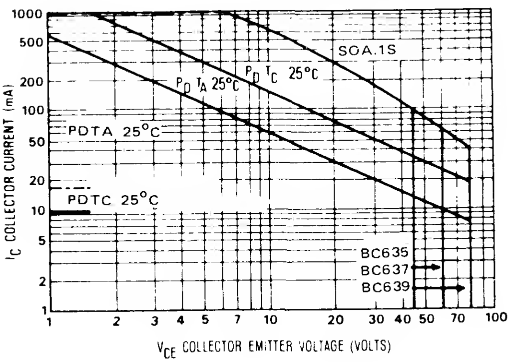


FIG. 2 — DC CURRENT GAIN

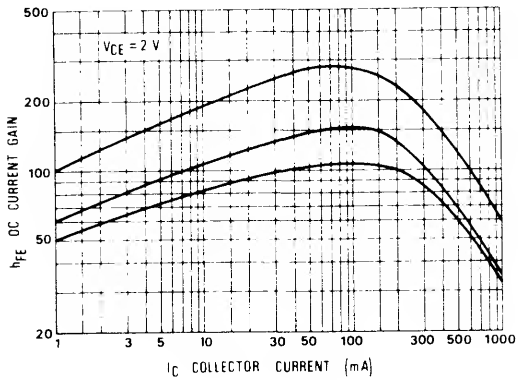


FIG. 3 — CURRENT GAIN BANDWIDTH PRODUCT

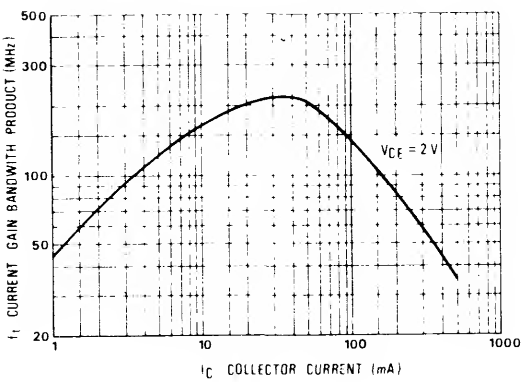


FIG. 4 — "SATURATION" AND "ON" VOLTAGES

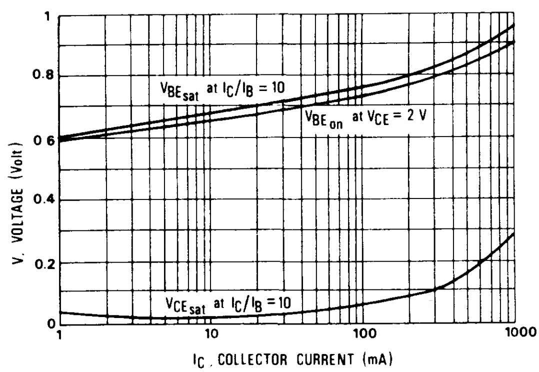
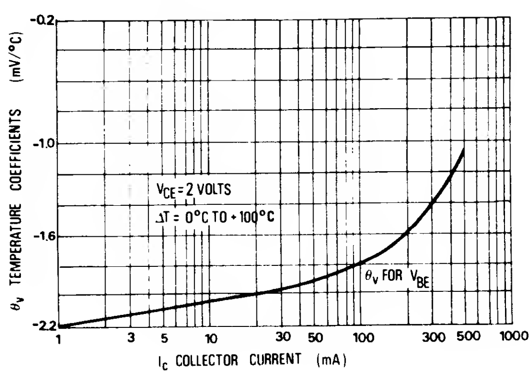


FIG. 5 — TEMPERATURE COEFFICIENTS



2

BC636
BC638
BC640

CASE 29-02, STYLE 14
TO-92 (TO-226AA)

HIGH CURRENT TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BC 636	BC 638	BC 640	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	Vdc
Collector-Base Voltage	V_{CBO}	45	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current − Continuous	I_C	1.0			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 6.4			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.75 22			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	45	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	156	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0) BC636 BC638 BC640	$V_{(BR)CEO}$	 45 60 80	 — — —	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 µAdc, I_E = 0) BC636 BC638 BC640	$V_{(BR)CBO}$	 45 60 80	 — — —	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	$V_{(BR)EBO}$	 5	 —	 —	Vdc
Collector Cutoff Current V_{CB} = 30 Vdc − I_E = 0 BC636 V_{CB} = 30 Vdc − I_E = 0 BC638 V_{CB} = 30 Vdc − I_E = 0 BC640	I_{CBO}	 — — —	 — — —	 100 100 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain (I_C = 5 mAdc, V_{CE} = 2.0 Vdc) (I_C = 150 mAdc, V_{CE} = 2.0 Vdc) BC636 BC638 BC640 (I_C = 500 mA, V_{CE} = 2 V)	h_{FE}	 25 40 40 40 25	 — — — — —	 — 250 160 160 —	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	— —	0.25 0.50	0.50 —	Vdc
Base-Emitter on Voltage (I_C = 500 mAdc, V_{CE} = 2 Vdc)	$V_{BE(on)}$	—		1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)	f_T	—	150	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	9	—	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	110	—	pF

* Pulse test - Pulse width ≤ 300 µs - Duty Cycle 2%

FIG. 1 — ACTIVE REGION SAFE OPERATING AREA

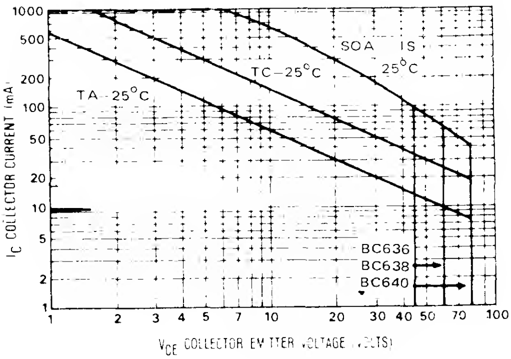


FIG. 2 — DC CURRENT GAIN

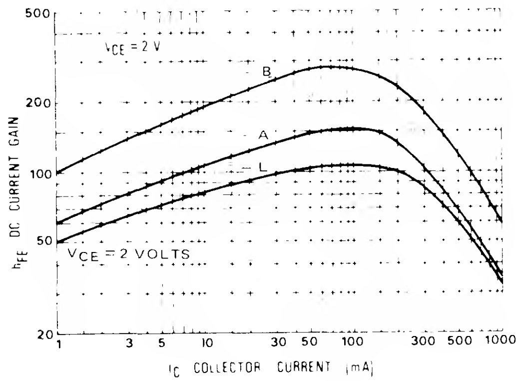


FIG. 3 — CURRENT GAIN BANDWIDTH PRODUCT

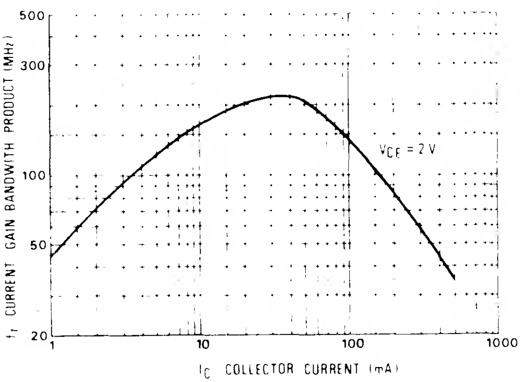


FIG. 4 — "SATURATION" AND "ON" VOLTAGES

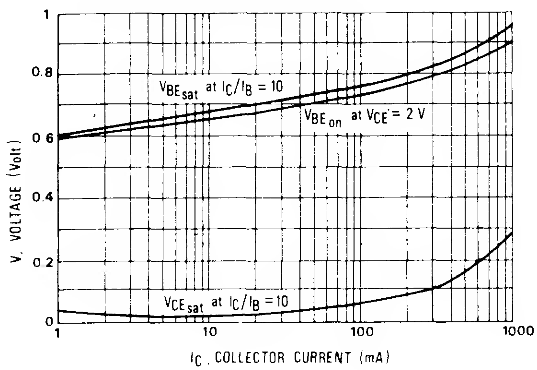
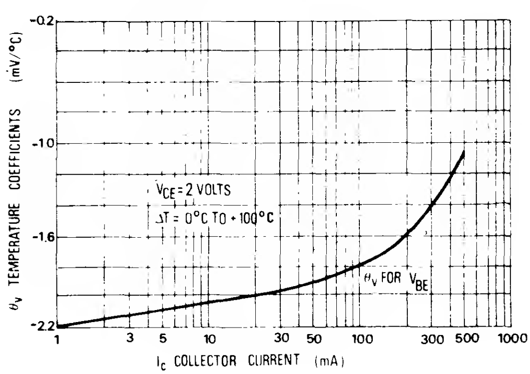


FIG. 5 — TEMPERATURE COEFFICIENTS



2

BC650, S
BC651, S

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

LOW NOISE AUDIO TRANSISTORS

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BC 650,S	BC 651,S	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	Vdc
Collector-Base Voltage	V_{CBO}	30	45	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current – Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BC650 BC651	$V_{(BR)CEO}$	30 45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BC650 BC651	$V_{(BR)CBO}$	30 45	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	0.015	μA
Collector-Emitter Leakage Current (V_{CE} = 60 V)		I_{CES}	—	0.025	μA
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	0.015	μA
ON CHARACTERISTICS					
DC Current Gain (I_C = 2 mAdc, V_{CE} = 5 Vdc)	BC650/BC651 BC650C/BC651C BC650D/BC651D	h_{FE}	380 380 680	1400 820 1400	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 100 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	— —	0.2 0.6	Vdc
Base Emitter On Voltage (I_C = 2 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.55	0.70	Vdc
SMALL SIGNAL CHARACTERISTICS					
Input Impedance (I_C = 2 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BC650C/BC651C BC650D/BC651D	h_{ie}	2.0 4.0	20 60	kΩ
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BC650C/BC651C BC650D/BC651D	h_{re}	1.0 2.0	30 60	$\times 10^{-4}$
Output Admittance (I_C = 2 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BC650C/BC651C BC650D/BC651D	h_{oe}	10 20	60 120	μmhos
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BC650/BC651	h_{fe}	380	1600	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	—	3.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	—	8.0	pF
Current Gain–Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 V, f = 100 MHz)		f_T	100	700	MHz

NOISE FIGURE/TOTAL NOISE VOLTAGE CHARACTERISTICS (V_{CE} = 5.0 V, I_C = 0.2 mA, T_A = 25°C

	NF Max. (1)	VT Max. (1)	NF Max. (2)	VT Max. (2)	NF Max. (3)	VT Max. (3)	Unit	
BC650, BC651, C, D	8	14.4	3.5	8.6	2.8	8	dB	nV
BC650S, BC651S, CS, DS	5	10.2	2.3	7.5	2	7.2	dB	nV

(1) RS = 2 kΩ, BW = 1.0 Hz, f = 10 Hz; (2) RS = 2 kΩ, BW = 1.0 Hz, f = 120 Hz; (3) RS = 2 kΩ, BW = 1.0 Hz, f = 1 KHz

2

BCX25
BCX27
BCX29

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPS8098 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BCX 25	BCX 27	BCX 29	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current – Continuous	I_C	200			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

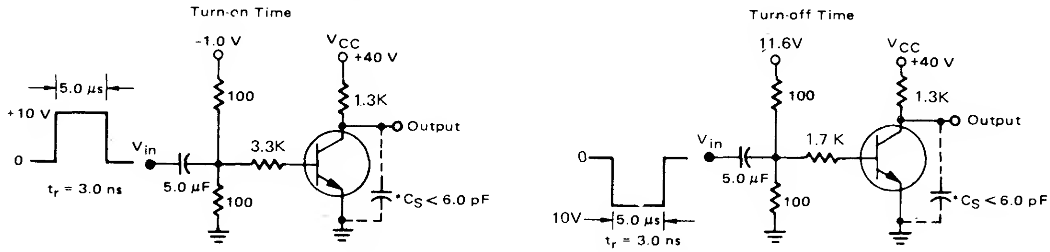
Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0) BCX25 BCX27 BCX29	$V_{(BR)CEO}$	 60 80 100			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) BCX25 BCX27 BCX29	$V_{(BR)CBO}$	 45 80 100			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0			Vdc
Collector Cutoff Current V_{CB} = 40 Vdc – I_E = 0 BCX25 V_{CB} = 60 Vdc – I_E = 0 BCX27 V_{CB} = 80 Vdc – I_E = 0 BCX29	I_{CBO}			 100 100 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain (I_C = 1 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 50 70 50	 150 250 300	 400 	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$		0.1	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$		0.85		Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$		0.68	1.0	Vdc

*Pulse test–Pulse width ≤ 300 μs – Duty cycle 2%

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

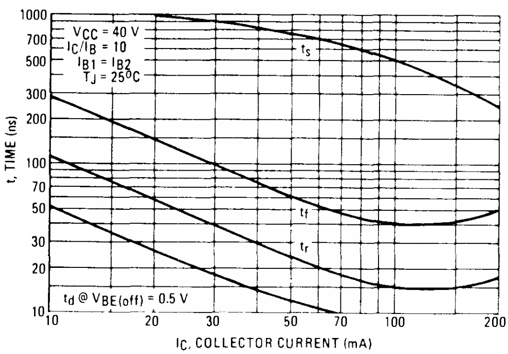
Characteristic	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS					
Current Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	250		MHz
Output Capacitance - Common Base (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}		3.0	6.0	pF
Input Capacitance - Common Base (V_{CB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}		16	25	pF
Noise Figure (I_C = 200 μAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 Kohm, f = 1.0 KHz, BW = 200 Hz)	N_F		2.0		dB
Input Impedance (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{ie}		1.3		Kohm
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{re}		$1.6 \cdot 10^{-4}$		
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{fe}		360		
Output Admittance (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{oe}		55		μmho
Turn - On delay Time ($V_{BE(off)}$ = 0.5 V, I_{B1} = 3 mA) (V_{CC} = 40 Vdc, I_C = 30 mAdc (see Figure 1)	t_d		19		ns
Rise Time ($V_{BE(off)}$ = 0.5 V, I_{B1} = 3 mA) (V_{CC} = 40 Vdc, I_C = 30 mAdc (see Figure 1)	t_r		40		ns
Storage Time (I_{B1} = I_{B2} = 3 mA) (V_{CC} = 40 Vdc, I_C = 30 mAdc (see Figure 1)	t_s		900		ns
Fall Time (I_{B1} = I_{B2} = 3 mA) (V_{CC} = 40 Vdc, I_C = 30 mAdc (see Figure 1)	t_f		100		ns

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors

FIGURE 2 – SWITCHING TIMES



BCX26
BCX28
BCX30

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPS8598 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	BCX 26	BCX 28	BCX 30	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current – Continuous	I_C	200			mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8			mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* ($I_C = 1$ mAdc, $I_B = 0$) BCX26 BCX28 BCX30	$V_{(BR)CEO}$	 60 80 100			Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ µAdc, $I_E = 0$) BCX26 BCX28 BCX30	$V_{(BR)CBO}$	 60 80 100			Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ µAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0			Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc − $I_E = 0$) BCX26 ($V_{CB} = 60$ Vdc − $I_E = 0$) BCX28 ($V_{CB} = 80$ Vdc − $I_E = 0$) BCX30	I_{CBO}			 100 100 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain ($I_C = 1$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 50 70 50	 150 160 120	 400 	
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$		0.125	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{BE(sat)}$		0.85		Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$		0.65	1.0	Vdc

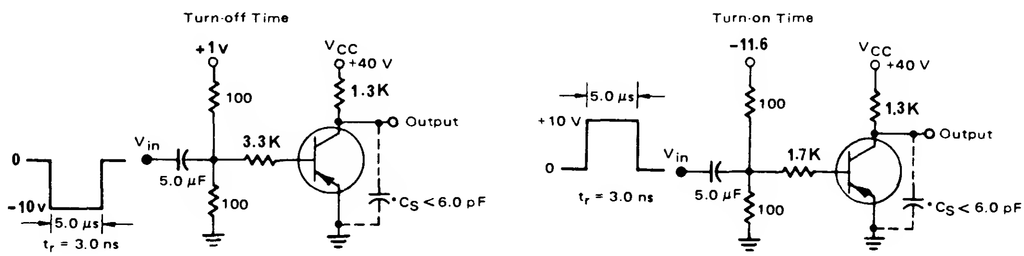
*Pulse test–Pulse width ≤ 300 µs – Duty cycle 2%

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

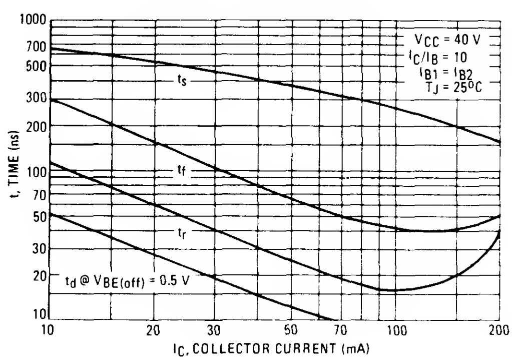
Characteristic	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS					
Current Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	220		MHz
Output Capacitance - Common Base (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}		3.0	6.0	pF
Input Capacitance - Common Base (V_{CB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}		20	30	pF
Noise Figure (I_C = 200 μAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 Kohm, f = 1.0 KHz, BW = 200 Hz)	N_F		2.0		dB
Input Impedance (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{ie}		730		ohm
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{re}		$1.3 \cdot 10^{-4}$		
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{fe}		180		
Output Admittance (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{oe}		140		μmho
Turn - On delay Time ($V_{BE(off)}$ = 0.5 V, I_{B1} = 3 mA) (V_{CC} = 40 Vdc, I_C = 30 mAdc (see Figure 1)	t_d		20		ns
Rise Time ($V_{BE(off)}$ = 0.5 V, I_{B1} = 3 mA) (V_{CC} = 40 Vdc, I_C = 30 mAdc (see Figure 1)	t_r		40		ns
Storage Time (I_{B1} = I_{B2} = 3 mA) (V_{CC} = 40 Vdc, I_C = 30 mAdc (see Figure 1)	t_s		450		ns
Fall Time (I_{B1} = I_{B2} = 3 mA) (V_{CC} = 40 Vdc, I_C = 30 mAdc (see Figure 1)	t_f		100		ns

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors

FIGURE 2 – SWITCHING TIMES



BCX45
BCX47
BCX49

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH CURRENT TRANSISTORS

NPN SILICON

Refer to MPSA05 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	BCX 45	BCX 47	BCX 49	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	Vdc
Collector-Base Voltage	V_{CBO}	45	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	1.0			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0) BCX45 BCX47 BCX49	$V_{(BR)CEO}$	 45 60 80			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) BCX45 BCX47 BCX49	$V_{(BR)CBO}$	 45 60 80			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	 5.0			Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc − I_E = 0) BCX45 (V_{CB} = 40 Vdc − I_E = 0) BCX47 (V_{CB} = 60 Vdc − I_E = 0) BCX49	I_{CBO}			 100 100 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 2.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	 40 50 30 15	 130 140 60		
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$		 0.2 0.3	 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$		 0.85		Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$		 0.85	 1.2	Vdc

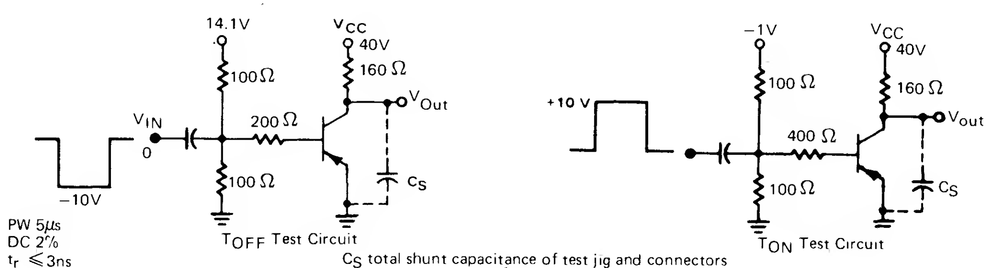
*Pulse test—Pulse width ≤ 300 μs − Duty cycle 2%

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

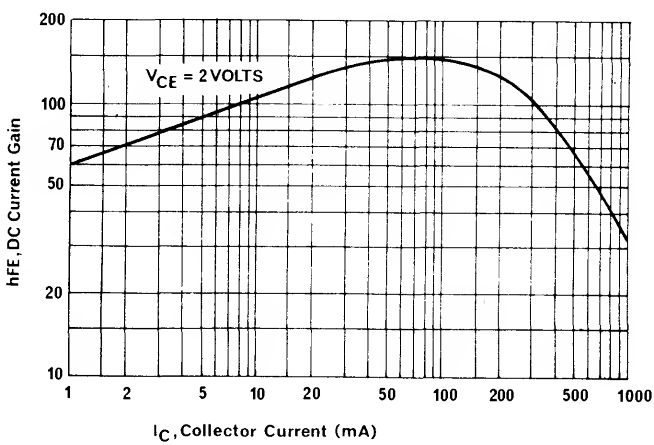
Characteristic	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS					
Current Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)	f_T	100	200		MHz
Output Capacitance - Common Base (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{ob}		7.0	12	pF
Input Capacitance - Common Base (V_{CB} = 0.5 Vdc, f = 1.0 MHz)	C_{ib}		50		pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{ie}		530		ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{re}		$1.1 \cdot 10^{-4}$		
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{fe}		120		
Output Admittance (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{oe}		58		µmho
Turn - On delay Time ($V_{BE(off)}$ = 0.5 V, I_{B1} = 3 mA) (V_{CC} = 40 Vdc, I_C = 250 mAdc (see Figure 1)	t_d		10		ns
Rise Time ($V_{BE(off)}$ = 0.5 V, I_{B1} = 3 mA) (V_{CC} = 40 Vdc, I_C = 250 mAdc (see Figure 1)	t_r		20		ns
Storage Time (I_{B1} = I_{B2} = 3 mA) (V_{CC} = 40 Vdc, I_C = 250 mAdc (see Figure 1)	t_s		330		ns
Fall Time (I_{B1} = I_{B2} = 3 mA) (V_{CC} = 40 Vdc, I_C = 250 mAdc (see Figure 1)	t_f		50		ns

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



C_S total shunt capacitance of test jig and connectors
$C_S \leqslant 6$pF

FIGURE 2 — DC CURRENT GAIN



BCX46
BCX48
BCX50

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH CURRENT TRANSISTORS

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BCX 46	BCX 48	BCX 50	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	Vdc
Collector-Base Voltage	V_{CBO}	45	60	80	Vdc
Emitter-Base Voltage	V_{EBO}		5.0		Vdc
Collector Current – Continuous	I_C		1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

Refer to MPSA55 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0) BCX46 BCX48 BCX50	$V_{(BR)CEO}$	 45 60 80			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) BCX46 BCX48 BCX50	$V_{(BR)CBO}$	 45 60 80			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	 5.0			Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc – I_E = 0) BCX46 (V_{CB} = 40 Vdc – I_E = 0) BCX48 (V_{CB} = 60 Vdc – I_E = 0) BCX50	I_{CBO}			 100 100 100	nAdc
ON CHARACTERISTICS*					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 2.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	 40 50 30 15	 130 140 60		
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$		 0.25 0.3	 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$		 0.9		Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$		 0.85	 1.2	Vdc

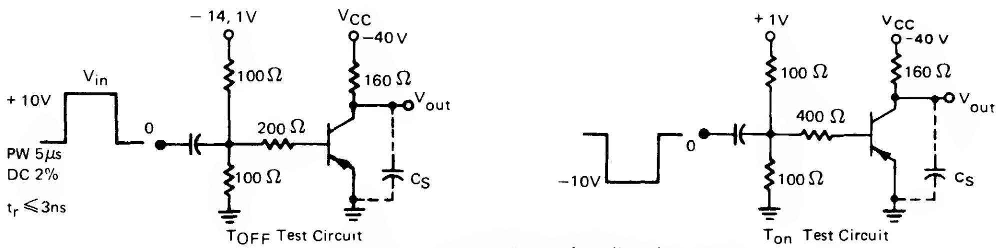
* Pulse test–Pulse width ≤ 300 μs – Duty cycle 2%

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

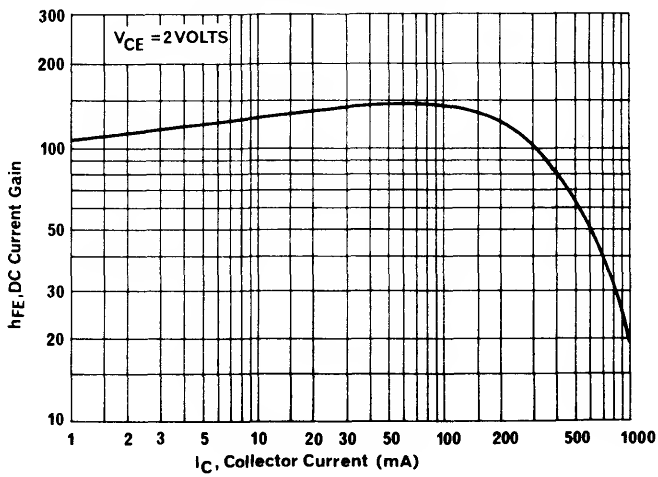
Characteristic	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS					
Current Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2.0 Vdc, f = 50 MHz)	f_T	60	130		MHz
Output Capacitance - Common Base (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{ob}		9.0	15	pF
Input Capacitance - Common Base (V_{CB} = 0.5 Vdc, f = 1.0 MHz)	C_{ib}		110		pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{ie}		700		ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{re}		$1.7 \cdot 10^{-4}$		
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{fe}		160		
Output Admittance (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 1.0 KHz)	h_{oe}		110		µmho
Turn - On delay Time ($V_{BE(off)}$ = 0.5 V, I_{B1} = 3 mA) (V_{CC} = 40 Vdc, I_C = 250 mAdc (see Figure 1)	t_d		12		ns
Rise Time ($V_{BE(off)}$ = 0.5 V, I_{B1} = 3 mA) (V_{CC} = 40 Vdc, I_C = 250 mAdc (see Figure 1)	t_r		28		ns
Storage Time (I_{B1} = I_{B2} = 3 mA) (V_{CC} = 40 Vdc, I_C = 250 mAdc (see Figure 1)	t_s		330		ns
Fall Time (I_{B1} = I_{B2} = 3 mA) (V_{CC} = 40 Vdc, I_C = 250 mAdc (see Figure 1)	t_f		50		ns

FIGURE 1 — SWITCHING TIME TEST CIRCUITS



C_S total shunt capacitance of test jig and connectors
$C_S \leq 6$pF

FIGURE 2 — DC CURRENT GAIN



BCX58
BCX59

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BCX 58	BCX 59	Unit
Collector-Emitter Voltage	V_{CEO}	32	45	Vdc
Collector-Base Voltage	V_{CBO}	32	45	Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current – Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BCX58 BCX59	$V_{(BR)CEO}$	32 45			Vdc
Emitter-Base Breakdown Voltage (I_E = 1 μAdc, I_C = 0)	all	$V_{(BR)EBO}$	7	8.7		Vdc
Collector Cutoff Current (V_{CE} = 32 V (V_{CE} = 45 V) (V_{CE} = 32 V, T_A = 100°C, V_{BE} = 0,2 V) (V_{CE} = 45 V, T_A = 100°C, V_{BE} = 0,2 V) (V_{CE} = 32 V, T_A = 125°C) (V_{CE} = 45 V, T_A = 125°C)	 BCX58 BCX59 BCX58 BCX59 BCX58 BCX59	 I_{CES} I_{CES} I_{CEX} I_{CEX} I_{CES} I_{CES}			 10 10 20 20 2.5 2.5	 nAdc μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5 Vdc)	 BCX59-7, BCX58-7 BCX59-8, BCX58-8 BCX59-9, BCX58-9 BCX59-10, BCX58-10	 h_{FE}	 20 40 75 100	 80 145 220 300		
(I_C = 2 mAdc, V_{CE} = 5 Vdc)	BCX59-7, BCX58-7 BCX59-8, BCX58-8 BCX59-9, BCX58-9 BCX59-10, BCX58-10		120 180 250 380	170 250 350 500	220 310 460 630	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	BCX59-7, BCX58-7 BCX59-8, BCX58-8 BCX59-9, BCX58-9 BCX59-10, BCX58-10		80 120 160 240	190 260 380 550	 400 630 1000	
(I_C = 100 mAdc, V_{CE} = 2 Vdc)	BCX59-7, BCX58-7 BCX59-8, BCX58-8 BCX59-9, BCX58-9 BCX59-10, BCX58-10		40 45 60 60			
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5 mAdc) (I_C = 10 mAdc, I_B = see note 1)		$V_{CE(sat)}$			 0.5 0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mA, I_B = 5 mA)		$V_{BE(sat)}$			1.3	Vdc
Base-Emitter On Voltage (I_C = 2 mAdc, V_{CE} = 5 Vdc)		$V_{BE(on)}$	0.55	0.62	0.70	Vdc

Note 1: I_C = 10 mA on the constant base current characteristic which yield the point I_C = 11 mA, V_{CE} = 5 V

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Current Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 V, f = 100 MHz)		f_T	200	350		MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1 MHz)		C_{ob}		1.8	4	pF
Input Capacitance (V_{BE} = 0,5 V, I_C = 0, f = 1 MHz)		C_{ib}		5.2	9	pF
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BCX58-7, BCX59-7 BCX58-8, BCX59-8 BCX58-9, BCX59-9 BCX58-10, BCX59-10	h_{fe}	125 175 250 350		250 350 500 700	
Output Admittance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BCX58-7, BCX59-7 BCX58-8, BCX59-8 BCX58-9, BCX59-9 BCX58-10, BCX59-10	h_{oe}			30 50 60 100	µmhos
Input Impedance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BCX58-7, BCX59-7 BCX58-8, BCX59-8 BCX58-9, BCX59-9 BCX58-10, BCX59-10	h_{ie}	1.6 2.5 3.2	2.7 3.6 4.5 7.5	4.5 6 8.5	Kohms
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BCX58-7, BCX59-7 BCX58-8, BCX59-8 BCX58-9, BCX59-9 BCX58-10, BCX59-10	h_{re}		1.5 2 2 3		X10^4
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5 Vdc, R_S = 2 KOhms, f = 1 KHz)		N_F		1	4	dB
(I_C = 10 mA, I_{B1} = 1 mA, I_{B2} = 1 mA) (V_{BB} = 3.6 V, R_1 = R_2 = 5 kΩ) (R_L = 999 ohms) * See test circuit		T_d T_r T_{on} T_s T_f T_{off}		16 29 45 475 40 515	 100 750	nS
(I_C = 100 mA, I_{B1} = 10 mA, I_{B2} = 10 mA) (V_{BB} = 5 V, R_1 = 500 Ω, R_2 = 700 Ω) (R_L = 98 ohms) * See test circuit		t_d t_r t_{on} t_s t_f t_{off}		5 40 45 135 80 215	 100 650	ns

TEST CIRCUIT

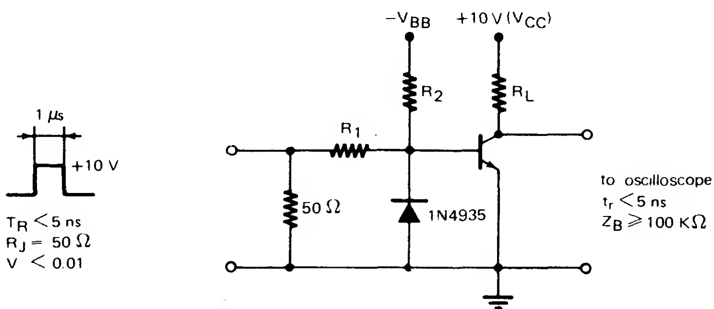


FIGURE 1 – NORMALIZED DC CURRENT GAIN

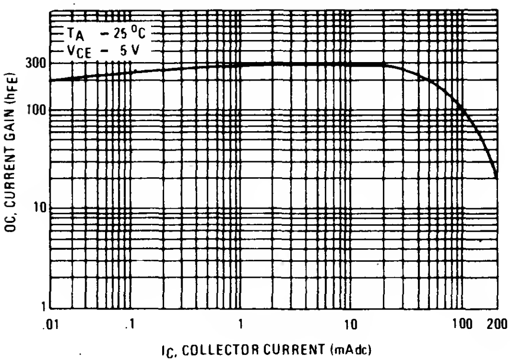


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

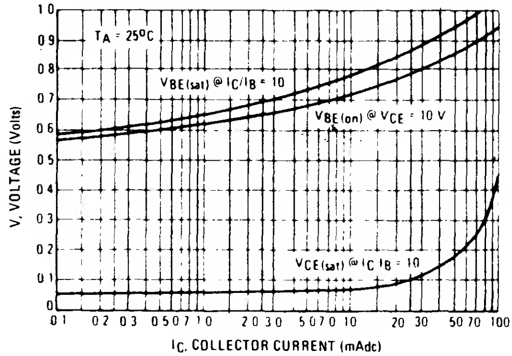


FIGURE 3 – COLLECTOR SATURATION REGION

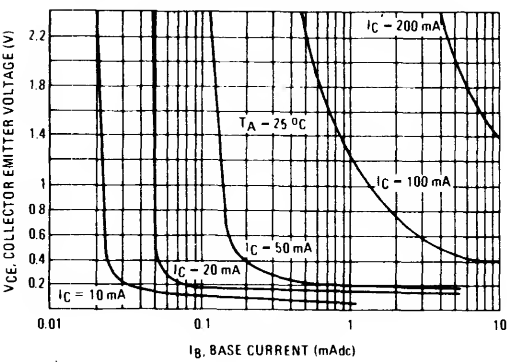


FIGURE 4 – BASE-EMITTER TEMPERATURE COEFFICIENT

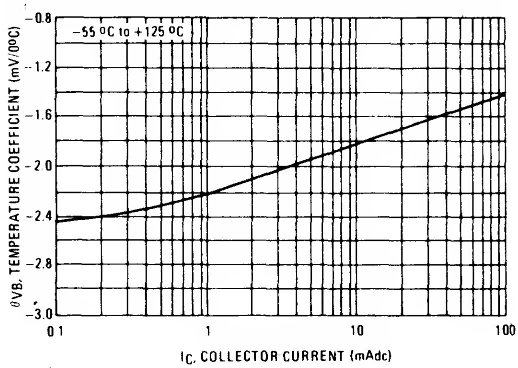


FIGURE 5 – CAPACITANCES

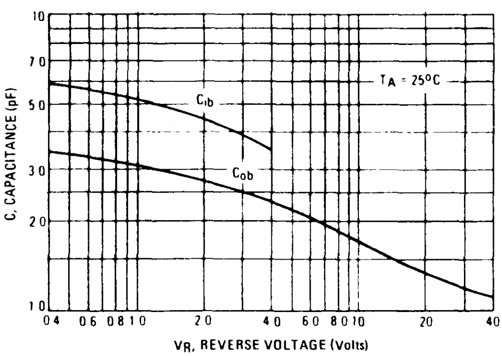
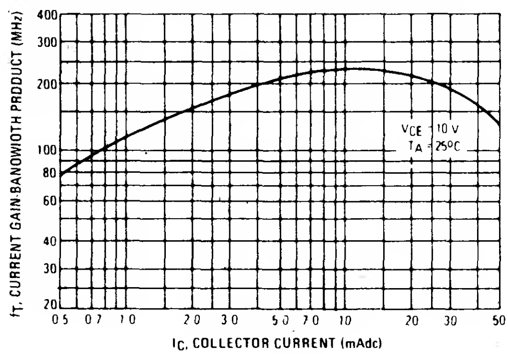


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT



2

BCX78
BCX79

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BCX 78	BCX 79	Unit
Collector-Emitter Voltage	V_{CEO}	32	45	Vdc
Collector-Base Voltage	V_{CBO}	32	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current − Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BCX78 BCX79	$V_{(BR)CEO}$	32 45			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	all	$V_{(BR)EBO}$	5	6.8		Vdc
Collector Cutoff Current						
(V_{CE} = 32 V	BCX78	I_{CES}			10	nAdc
(V_{CE} = 45 V)	BCX79	I_{CES}			10	
(V_{CE} = 32 V, T_A = 100°C, V_{BE} = 0,2 V)	BCX78	I_{CEX}			20	μAdc
(V_{CE} = 45 V, T_A = 100°C, V_{BE} = 0,2 V)	BCX79	I_{CEX}			20	
(V_{CE} = 32 V, T_A = 125°C)	BCX78	I_{CES}			2.5	
(V_{CE} = 45 V, T_A = 125°C)	BCX79	I_{CES}			2.5	
ON CHARACTERISTICS						
DC Current Gain						
(I_C = 10 μAdc, V_{CE} = 5 Vdc)	BCX79-7, BCX78-7	h_{FE}	20	140		
	BCX79-8, BCX78-8		40	200		
	BCX79-9, BCX78-9		75	270		
	BCX79-10, BCX78-10		100	340		
(I_C = 2 mAdc, V_{CE} = 5 Vdc)	BCX79-7, BCX78-7		120	170	220	
	BCX79-8, BCX78-8		180	250	310	
	BCX79-9, BCX78-9		250	350	460	
	BCX79-10, BCX78-10		380	500	630	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	BCX79-7, BCX78-7		80	180		
	BCX79-8, BCX78-8		120	260	400	
	BCX79-9, BCX78-9		160	360	630	
	BCX79-10, BCX78-10		240	500	1000	
(I_C = 100 mAdc, V_{CE} = 2 Vdc)	BCX79-7, BCX78-7		40			
	BCX79-8, BCX78-8		45			
	BCX79-9, BCX78-9		60			
	BCX79-10, BCX78-10		60			
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5 mAdc) (I_C = 10 mAdc, I_B = see note 1)		$V_{CE(sat)}$			0.5 0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mA, I_B = 5 mA)		$V_{BE(sat)}$			1.1	Vdc
Base-Emitter On Voltage (I_C = 2 mAdc, V_{CE} = 5 Vdc)		$V_{BE(on)}$	0.55	0.62	0.70	Vdc

Note 1: I_C = 10 mA on the constant base current characteristic which yield the point I_C = 11 mA, V_{CE} = 5 V

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
SMALL SIGNAL CHARACTERISTICS						
Current Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 V, f = 100 MHz)		f_T	250	400		MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1 MHz)		C_{ob}		2.6	4.5	pF
Input Capacitance (V_{BE} = 0,5 V, I_C = 0, f = 1 MHz)		C_{ib}		8.5	11	pF
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BCX78-7, BCX79-7 BCX78-8, BCX79-8 BCX78-9, BCX79-9 BCX78-10, BCX79-10	h_{fe}	125 175 250 350	200 260 330 520	250 350 500 700	
Output Admittance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BCX78-7, BCX79-7 BCX78-8, BCX79-8 BCX78-9, BCX79-9 BCX78-10, BCX79-10	h_{oe}			30 50 60 100	μmhos
Input Impedance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BCX78-7, BCX79-7 BCX78-8, BCX79-8 BCX78-9, BCX79-9 BCX78-10, BCX79-10	h_{ie}	1.6 2.5 3.2	2.7 3.6 4.5 7.5	4.5 6 8.5	Kohms
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	BCX78-7, BCX79-7 BCX78-8, BCX79-8 BCX78-9, BCX79-9 BCX78-10, BCX79-10	h_{re}		1.5 2 2 3		$X10^4$
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5 Vdc, R_g = 2 KOhms, f = 1 KHz)		NF		1	3	dB
(I_C = 10 mA, I_{B1} = 1 mA, I_{B2} = 1 mA) (V_{BB} = 3.6 V, R_1 = R_2 = 5 kΩ) (R_L = 999 ohms) * See test circuit		T_d T_r T_{on} T_s T_f T_{off}		17 27 44 400 60 460	 100 750	nS
(I_C = 100 mA, I_{B1} = 10 mA, I_{B2} = 10 mA) (V_{BB} = 5 V, R_1 = 500 Ω, R_2 = 700 Ω) (R_L = 98 ohms) * See test circuit		t_d t_r t_{on} t_s t_f t_{off}		5 20 25 130 40 170	 100 650	ns

TEST CIRCUIT

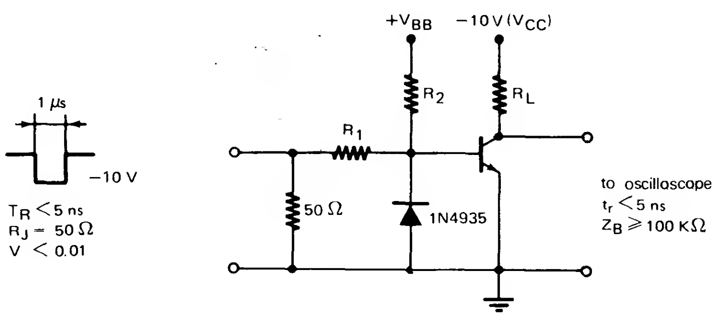


FIGURE 1 – NORMALIZED DC CURRENT GAIN

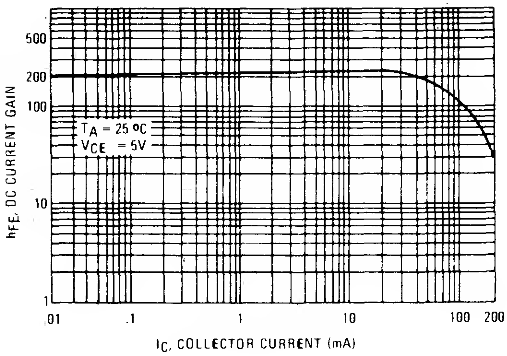


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

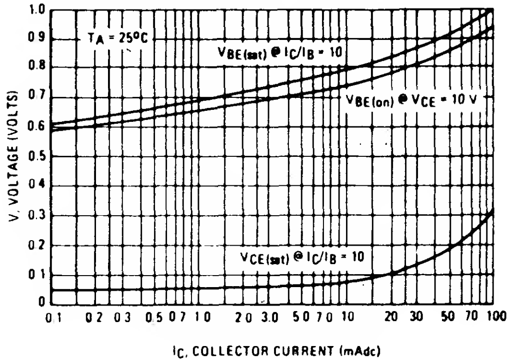


FIGURE 3 – COLLECTOR SATURATION REGION

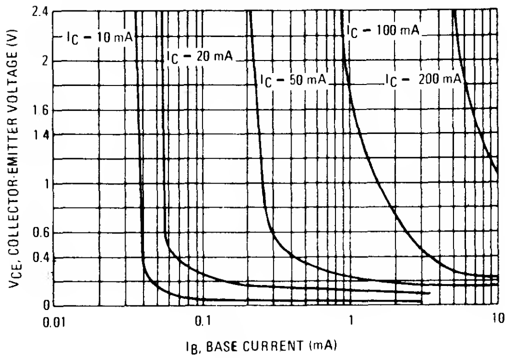


FIGURE 4 – BASE EMITTER TEMPERATURE COEFFICIENT

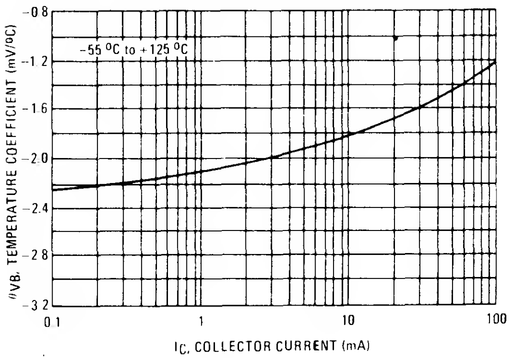


FIGURE 5 – CAPACITANCES

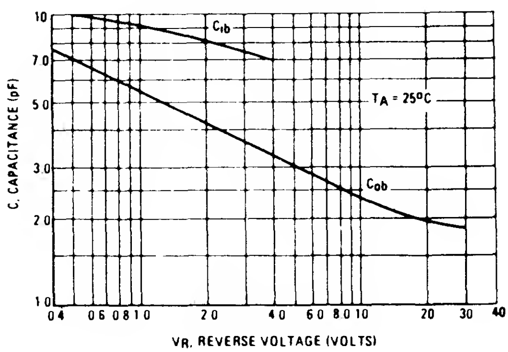
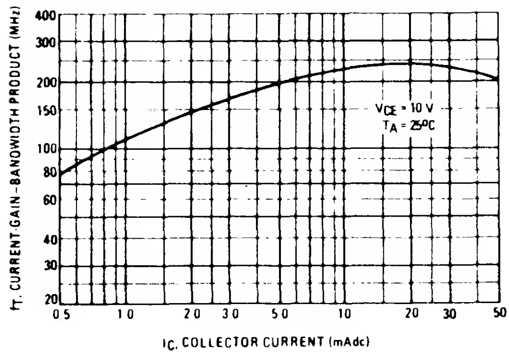


FIGURE 6 – CURRENT GAIN-BANDWIDTH PRODUCT



BDB01A Thru BDB01D

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

ONE WATT AMPLIFIER TRANSISTORS

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BDB 01A	BDB 01B	BDB 01C	BDB 01D	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	100	Vdc
Collector-Base Voltage	V_{CES}	45	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0				Vdc
Collector Current − Continuous	I_C	0.5				Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0				Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20				Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage (I_C = 10 mA, I_B = 0) BDB01A BDB01B BDB01C BDB01D	$V_{(BR)CEO}$	 45 60 80 100		Vdc
Collector Cutoff Current (V_{CB} = 45 V, I_E = 0) (V_{CB} = 60 V, I_E = 0) (V_{CB} = 80 V, I_E = 0) (V_{CB} = 100 V, I_E = 0)	I_{CBO}		 0.1 0.1 0.1 0.1	µAdc
Emitter Cutoff Current (I_C = 0, V_{EB} = 5.0 V)	I_{EBO}		100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mA, V_{CE} = 1 V) (I_C = 500 mA, V_{CE} = 2 V)	h_{FE}	 40 25	 400	
Collector-Emitter Saturation Voltage (I_C = 1000 mA, I_B = 100 mA)	$V_{CE(sat)}$		0.7	Vdc
Collector-Emitter on Voltage (I_C = 1000 mA, V_{CE} = 1 V)	$V_{BE(on)}$		1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 200 mA, V_{CE} = 5 V, f = 100 MHz)	f_T	50		MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}		30	pF

FIGURE 1 – D.C. CURRENT GAIN

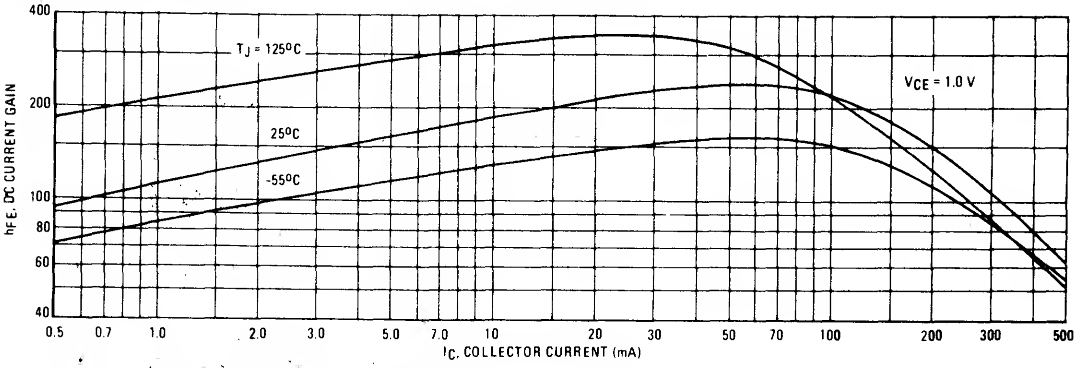


FIGURE 2 – COLLECTOR SATURATION REGION

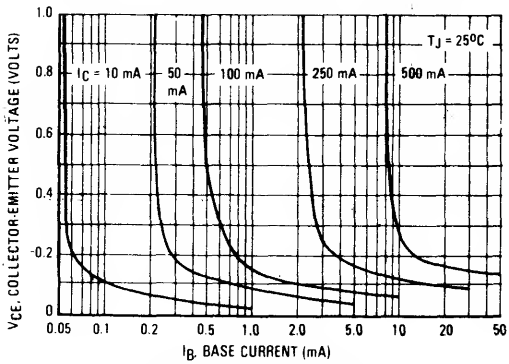


FIGURE 3 – ON VOLTAGES

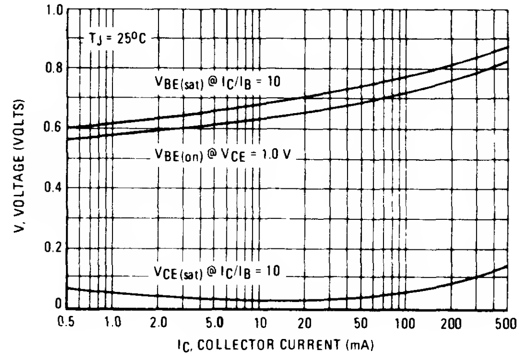


FIGURE 4 – BASE-EMITTER TEMPERATURE COEFFICIENT

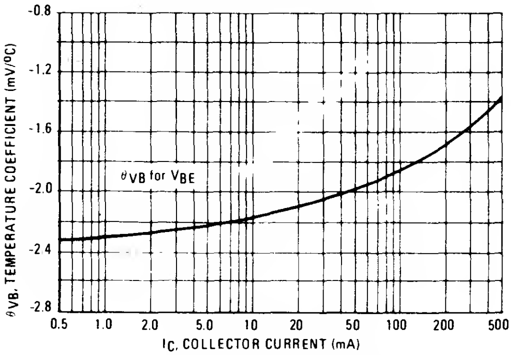


FIGURE 5 – CAPACITANCE

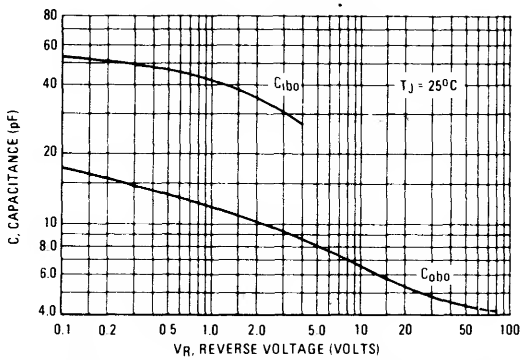


FIGURE 6 – CURRENT GAIN-BANDWIDTH PRODUCT

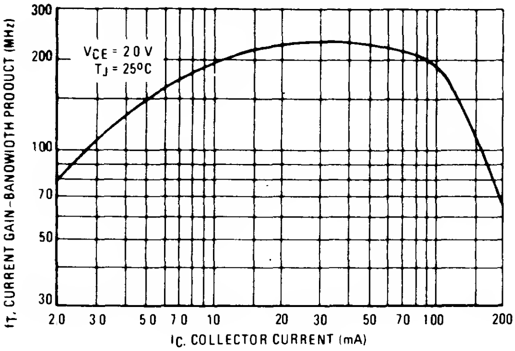
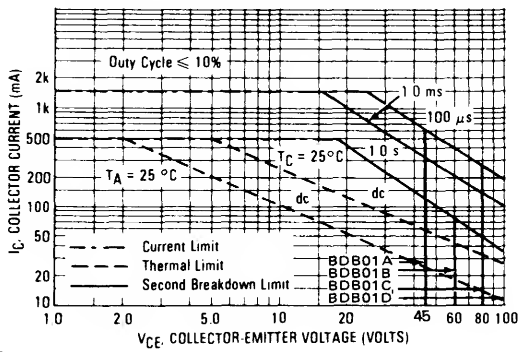


FIGURE 7 – ACTIVE REGION-SAFE OPERATING AREA



BDB02A Thru BDB02D

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

ONE WATT AMPLIFIER TRANSISTORS

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	BDB 02A	BDB 02B	BDB 02C	BDB 02D	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	100	Vdc
Collector-Base Voltage	V_{CES}	45	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0				Vdc
Collector Current – Continuous	I_C	0.5				Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0				Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20				Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage (I_C = 10 mA, I_B = 0) BDB02A BDB02B BDB02C BDB02D	$V_{(BR)CEO}$	 45 60 80 100		Vdc
Collector Cutoff Current (V_{CB} = 45 V, I_E = 0) (V_{CB} = 60 V, I_E = 0) (V_{CB} = 80 V, I_E = 0) (V_{CB} = 100 V, I_E = 0)	I_{CBO}		 0.1 0.1 0.1 0.1	μAdc
Emitter Cutoff Current (I_C = 0, V_{EB} = 5.0 V)	I_{EBO}		100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mA, V_{CE} = 1 V) (I_C = 500 mA, V_{CE} = 2 V)	h_{FE}	 40 25	 400	
Collector-Emitter Saturation Voltage (I_C = 1000 mA, I_B = 100 mA)	$V_{CE(sat)}$		0.7	Vdc
Collector-Emitter on Voltage (I_C = 1000 mA, V_{CE} = 1 V)	$V_{BE(on)}$		1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 200 mA, V_{CE} = 5 V, f = 100 MHz)	f_T	50		MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}		30	pF

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FIGURE 1 – D.C. CURRENT GAIN

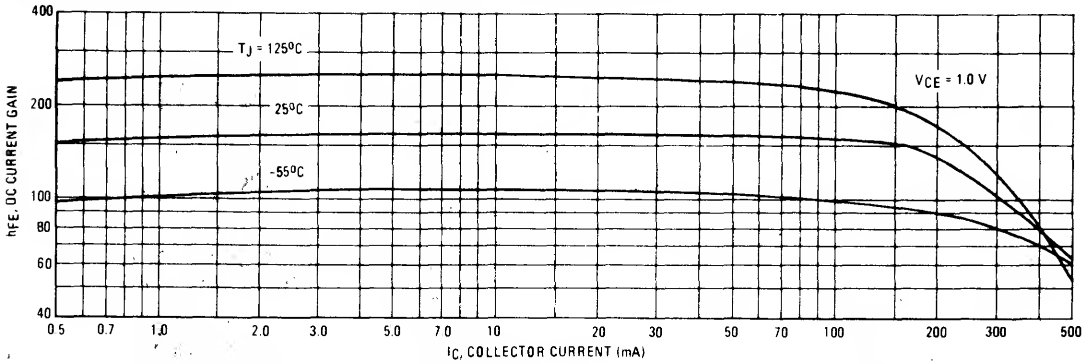


FIGURE 2 – COLLECTOR SATURATION REGION

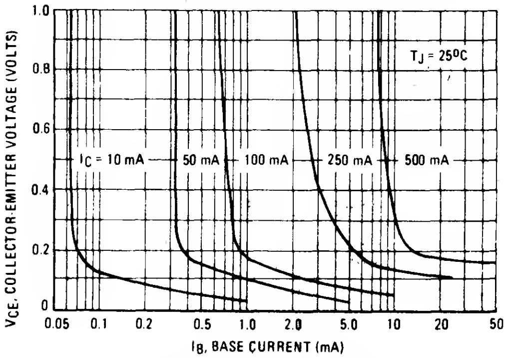


FIGURE 3 – ON VOLTAGES

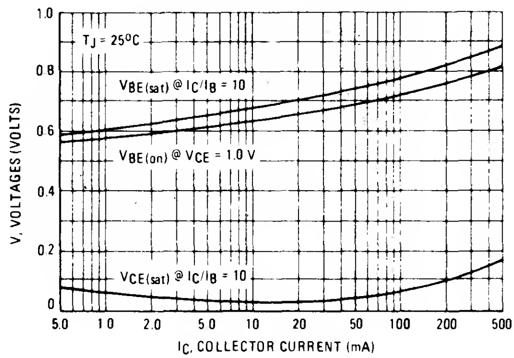


FIGURE 4 – BASE-EMITTER TEMPERATURE COEFFICIENT

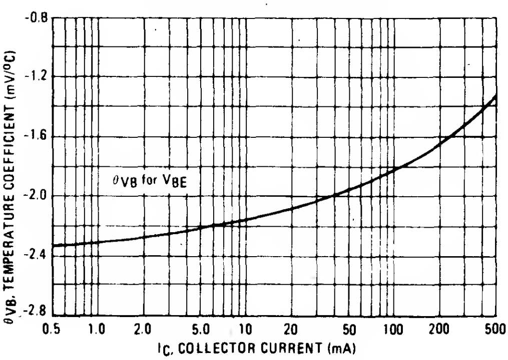


FIGURE 5 – CAPACITANCE

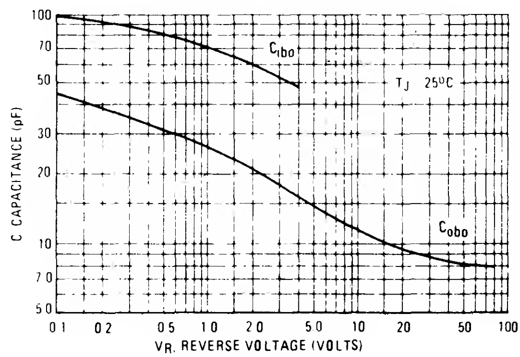


FIGURE 6 – CURRENT GAIN-BANDWIDTH PRODUCT

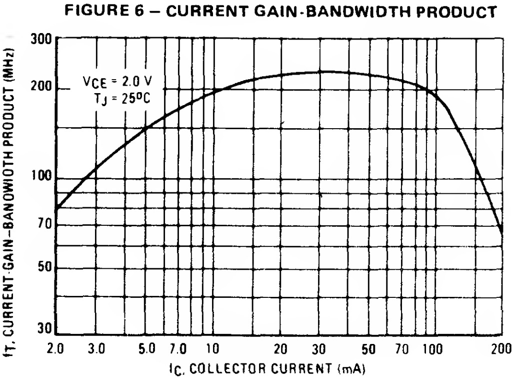
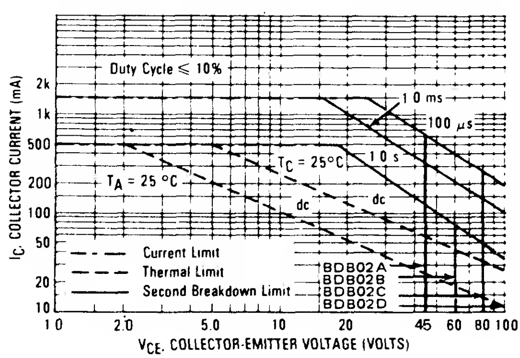


FIGURE 7 – ACTIVE REGION-SAFE OPERATING AREA



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BDB03

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

ONE WATT
AMPLIFIER TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current − Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

Refer to BDB01A for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CES}$	45	—	—	Vdc
Collector Cutoff Current (V_{CB} = 45 V, I_E = 0)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 4 V, I_C = 0)	I_{EBO}	—	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 150 mA, V_{CE} = 10 V) (I_C = 1 A, V_{CE} = 10 V)	h_{FE}	 100 15	 — —	 300 —	—
Collector-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA)	$V_{CE(sat)}$	—	—	1.1	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA)	$V_{BE(sat)}$	—	—	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 100 MHz)	f_T	150	—	—	MHz
Collector-Base Capacitance (V_{CB} = 10 V, f = 1 MHz)	C_{cb}	—	—	15	pF

2

BDB04

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

ONE WATT AMPLIFIER TRANSISTORS

PNP SILICON

Refer to BDB02A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current − Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CES}$	45	—	—	Vdc
Collector Cutoff Current (V_{CB} = 45 V, I_E = 0)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 4 V, I_C = 0)	I_{EBO}	—	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 150 mA, V_{CE} = 10 V) (I_C = 1 A, V_{CE} = 10 V)	h_{FE}	 100 15	 — —	 300 —	—
Collector-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA)	$V_{CE(sat)}$	—	—	1.1	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA)	$V_{BE(sat)}$	—	—	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 100 MHz)	f_T	150	—	—	MHz
Collector-Base Capacitance (V_{CB} = 10 V, f = 1 MHz)	C_{cb}	—	—	15	pF

BDB05

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

ONE WATT
HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	B0	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current − Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 B.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 30 mA, I_B = 0)	$V_{(BR)CEO}$	B0		Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	120		Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0		Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}		10 10	nA μA
Emitter Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)	I_{EBO}		10	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc) (1) (I_C = 1 mAdc, V_{CE} = 10 Vdc) (1)	H_{FE}	 50 90 100 50 15	 300	
Collector Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$		 0.2 0.5	Vdc
Base Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$		1.1	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100		MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{ob}		12	pF
Input Capacitance (V_{BF} = 0.5 Vdc, I_C = 0, f = 1 MHz)	C_{ib}		60	pF
Small Signal Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 KHz)	h_{fe}	B0		400

(1) Pulse Test: Pulse width < 300 μS — duty cycle ≤ 2%.

2

BDB06

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

ONE WATT AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	$V_{(BR)CEO}$	80		V
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)	$V_{(BR)CBO}$	80		V
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	$V_{(BR)EBO}$	5		V
Emitter Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)	I_{EBO}		10	μA
Collector Cutoff Current (V_{CB} = 50 V, I_E = 0) (V_{CB} = 50 V, I_E = 0, T_A = 150°C)	I_{CBO}		 50 50	 nA μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mA, V_{CE} = 5 V) (I_C = 100 mA, V_{CE} = 5 Vdc) (I_C = 500 mA, V_{CE} = 5 Vdc) (1) (I_C = 1 A, V_{CE} = 5 Vdc) (1)	H_{FE}	 75 100 70 25	 300	
Collector-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$		 0.15 0.5	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$		0.9	V
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 0.5 V)	$V_{BE(on)}$		1.1	V
DYNAMIC CHARACTERISTICS				
Current Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc)	f_T	150		MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{ob}		20	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 1 MHz)	C_{ib}		110	pF
Turn on Time (V_{CC} = 30 V, I_C = 500 mA) I_B = 50 mA) Turn off Time	T_{on} T_{off}		 100 400	ns

(1) Pulse Test: Pulse width < 300 μS — Duty Cycle < 2%.

BDC01A Thru BDC01D

CASE 29-03, STYLE 14
TO-92 (TO-226AE)

ONE WATT
AMPLIFIER TRANSISTORS

NPN SILICON

Refer to BDB01A for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	BDC 01A	BDC 01B	BDC 01C	BDC 01D	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	45	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0				Vdc
Collector Current – Continuous	I_C	1.5				Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0				Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20				Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage (I_C = 10 mA, I_B = 0) BDC01A BDC01B BDC01C BDC01D	$V_{(BR)CEO}$	 45 60 80 100		Vdc
Collector Cutoff Current (V_{CB} = 45 V, I_E = 0) (V_{CB} = 60 V, I_E = 0) (V_{CB} = 80 V, I_E = 0) (V_{CB} = 100 V, I_E = 0)	I_{CBO}		 0.1 0.1 0.1 0.1	μAdc
Emitter Cutoff Current (I_C = 0, V_{EB} = 5.0 V)	I_{EBO}		100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mA, V_{CE} = 1 V) (I_C = 500 mA, V_{CE} = 2 V)	h_{FE}	 40 25	 400	
Collector-Emitter Saturation Voltage (I_C = 1000 mA, I_B = 100 mA)	$V_{CE(sat)}$		0.7	Vdc
Collector-Emitter on Voltage (I_C = 1000 mA, V_{CE} = 1 V)	$V_{BE(on)}$		1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 200 mA, V_{CE} = 5 V, f = 100 MHz)	f_T	50		MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}		30	pF

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BDC02A Thru BDC02D

CASE 29-03, STYLE 14
TO-92 (TO-226AE)

ONE WATT
AMPLIFIER TRANSISTORS

Refer to BDB02A for graphs.

MAXIMUM RATINGS

Rating	Symbol	BDC 02A	BDC 02B	BDC 02C	BDC 02D	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	45	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0				Vdc
Collector Current – Continuous	I_C	1.5				Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0				Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20				Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage ($I_C = 10$ mA, $I_B = 0$) BDC02A BDC02B BDC02C BDC02D	$V_{(BR)CEO}$	 45 60 80 100		Vdc
Collector Cutoff Current ($V_{CB} = 45$ V, $I_E = 0$) ($V_{CB} = 60$ V, $I_E = 0$) ($V_{CB} = 80$ V, $I_E = 0$) ($V_{CB} = 100$ V, $I_E = 0$)	I_{CBO}		 0.1 0.1 0.1 0.1	μAdc
Emitter Cutoff Current ($I_C = 0$, $V_{EB} = 5.0$ V)	I_{EBO}		100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 100$ mA, $V_{CE} = 1$ V) ($I_C = 500$ mA, $V_{CE} = 2$ V)	h_{FE}	 40 25	 400	
Collector-Emitter Saturation Voltage ($I_C = 1000$ mA, $I_B = 100$ mA)	$V_{CE(sat)}$		0.7	Vdc
Collector-Emitter on Voltage ($I_C = 1000$ mA, $V_{CE} = 1$ V)	$V_{BE(on)}$		1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain Bandwidth Product ($I_C = 200$ mA, $V_{CE} = 5$ V, f = 100 MHz)	f_T	50		MHz
Output Capacitance ($V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz)	C_{ob}		30	pF

BDC03

CASE 29-03, STYLE 14
TO-92 (TO-226AE)

ONE WATT AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSW01 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1 Vdc) (I_C = 5 mAdc, V_{CE} = 10 Vdc) (I_C = 1000 mAdc, V_{CE} = 1 Vdc)	h_{FE}	 87 50 60	 375 — —	—
Collector-Emitter Saturation Voltage (I_C = 1000 mAdc, I_B = 100 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	—	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	20	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

2

BDC04

CASE 29-03, STYLE 14
TO-92 (TO-226AE)

ONE WATT
AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MPSW51 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current − Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1 Vdc) (I_C = 5 mAdc, V_{CE} = 10 Vdc) (I_C = 1000 mAdc, V_{CE} = 1 Vdc)	h_{FE}	 85 50 60	 375 — —	—
Collector-Emitter Saturation Voltage (I_C = 1000 mAdc, I_B = 100 mAdc)	$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter On Voltage (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	—	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	30	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

2

BDC05
BDC07

CASE 29-03, STYLE 14
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSW42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BDC 05	BDC 07	Unit
Collector-Emitter Voltage	V_{CEO}	300	250	Vdc
Collector-Base Voltage	V_{CBO}	300	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 50		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_B = 0)	BDC05 BDC07	$V_{(BR)CEO}$	300 250	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BDC05 BDC07	$V_{(BR)CBO}$	300 250	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BDC05 BDC07	$V_{(BR)EBO}$	5.0 5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	BDC05 BDC07	I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	BDC05 BDC07	I_{EBO}	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 25 mAdc, V_{CE} = 20 Vdc)	BDC05 BDC07	h_{FE}	40 50	— —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$		2	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mA, I_B = 2.0 mA)		$V_{BE(sat)}$		2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 50 MHz)		f_T	60	—	MHz
Collector-Base Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		2.8	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

2

BDC06
BDC08

CASE 29-03, STYLE 14
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSW92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BDC 06	BDC 08	Unit
Collector-Emitter Voltage	V_{CEO}	300	250	Vdc
Collector-Base Voltage	V_{CBO}	300	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current − Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_B = 0)	BDC06 BDC08	$V_{(BR)CEO}$	300 250	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BDC06 BDC08	$V_{(BR)CBO}$	300 250	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BDC06 BDC08	$V_{(BR)EBO}$	5.0 5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	BDC06 BDC08	I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	BDC06 BDC08	I_{EBO}	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 25 mA, V_{CE} = 20 Vdc)	BDC06 BDC08	h_{FE}	40 50	— —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$		2	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mA, I_B = 2.0 mA)		$V_{BE(sat)}$		2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain−Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 50 MHz)		f_T	60	—	MHz
Collector-Base Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		2.8	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

BF199

CASE 29-02, STYLE 21
TO-92 (TO-226AA)

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

Refer to BF240 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2 mAdc, I_B = 0)	$V_{(BR)CEO}$	25			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4			Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}			100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 7 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	85		
Base-Emitter On Voltage (I_C = 7 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$		770	900	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain–Bandwidth Product (2) (I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	750		MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}		0.25	0.35	pF
Noise Figure (I_C = 4 mA, V_{CE} = 10 V, R_S = 50 Ω, f = 35 MHz)	N_f		2.5		dB

BF224

CASE 29-02, STYLE 21
TO-92 (TO-226AA)

RF TRANSISTOR

NPN SILICON

Refer to BF240 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	$V_{(BR)CEO}$	30			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	45			Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4			Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) T_A = 25°C T_A = 85°C	I_{CBO}			100 10	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}			100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 7 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30			
Base-Emitter On Voltage (I_C = 7 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$		0.77	0.9	mVdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$			0.15	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain–Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 7 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	600 850		MHz
Common Emitter Feedback Capacitance (V_{CE} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{re}		0.28		pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 100 MHz) f = 200 MHz	N_f		2.5 3.5		dB

BF240
BF241

CASE 29-02, STYLE 21
TO-92 (TO-226AA)

AM/FM TRANSISTORS

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current − Continuous	I_C	25	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 2 mAdc, I_B = 0)		$V_{(BR)CEO}$	40			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	40			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4			Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}			100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1 mAdc, V_{CE} = 10 Vdc)	BF240 BF241	h_{FE}	65 35		220 125	—
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	.65	.70	.74	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current Gain−Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	BF240 BF241	f_T		600 470		MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		.28	.34	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, R_S = 200 Ω, f = 100 KHz) R_S = 50 Ω, f = 100 MHz		N_f		2.5	3.5	dB
Output Admittance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 450 KHz) (f = 10.7 MHz)		g_{oe}			8.3 10.5	μmho

(1) Pulse test: Pulse Width ≦ 300 μs. Duty cycle ≦ 2.0%.

FIGURE 1 – CURRENT GAIN-BANDWIDTH PRODUCT

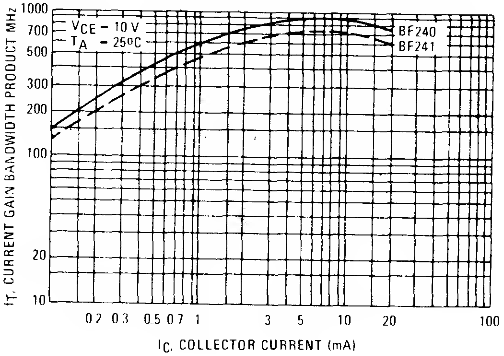


FIGURE 2 – CAPACITANCES

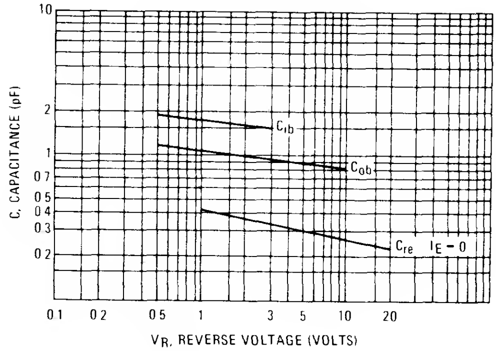


FIGURE 3 – DC CURRENT GAIN

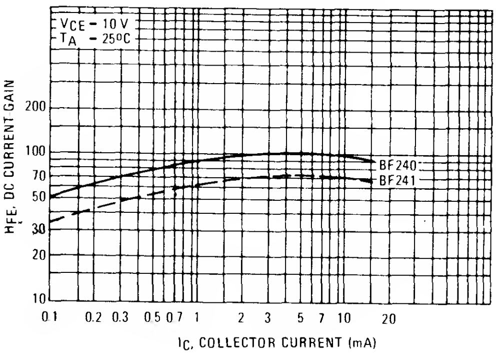


FIGURE 4 – b11e

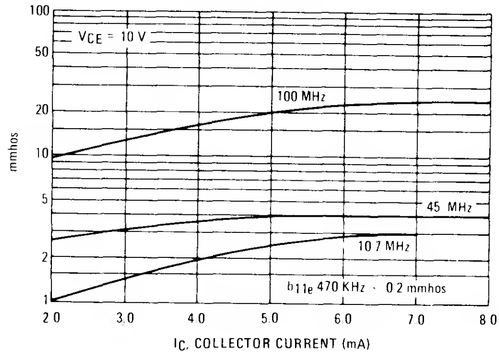


FIGURE 5 – b21e

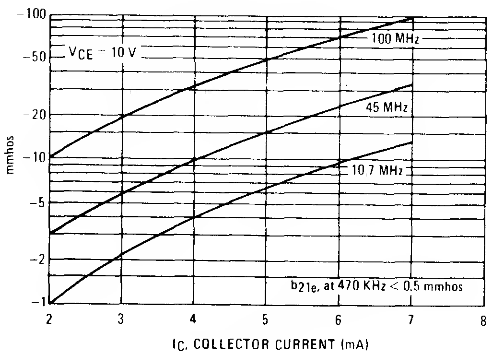


FIGURE 6 – b22e (boe)

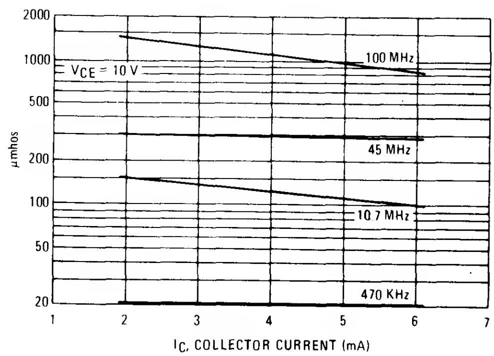


FIGURE 7 — g11e (gie)

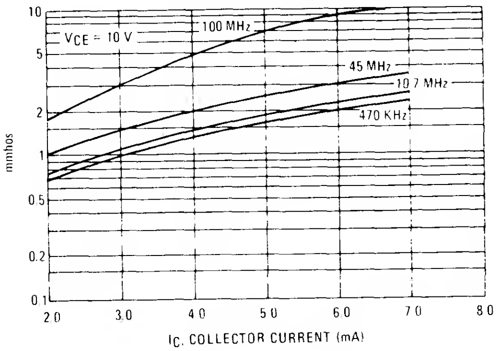


FIGURE 8 — g21e (Yfe)

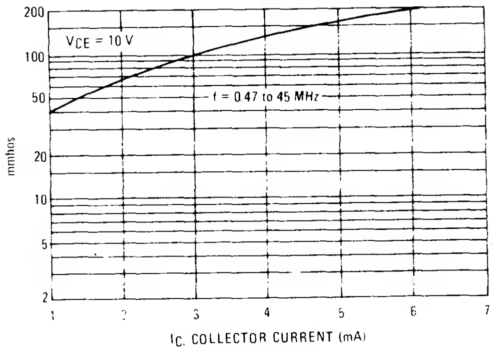
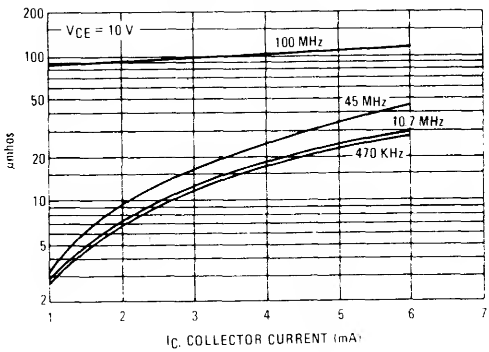


FIGURE 9 — g22e (goe)



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2

BF254
BF255

CASE 29-02, STYLE 21
TO-92 (TO-226AA)

AM/FM TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	20			Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	30			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0			Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}			100	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}			100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mA, V_{CE} = 10 Vdc)	BF254 BF254-3 BF254-4 BF255 BF255-2 BF255-3	h_{FE}	65 65 100 35 35 65		220 125 220 125 75 125	
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	BF254 BF255	$V_{BE(on)}$		.68		Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current Gain–Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	BF254 BF255	f_T		260 200		MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		0.90		pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1 MHz, R_S = 50 ohms)		N_f		1.7		dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

TYPICAL ADMITTANCE PARAMETERS (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, frequency as stated)

Symbol	f = 450 KHz		f = 10.7 MHz		Unit
	BF254	BF255	BF254	BF255	
g_{11e}	0.20	0.40	0.26	0.5	mmhos
b_{11e}	0.05	0.06	1.2	1.6	mmhos
g_{22e}	3.0	1.5	5.3	4.5	μmhos
b_{22e}	8.0	8.0	190	190	μmhos
b_{12e}	− 5.0	− 5.0	− 130	− 130	μmhos
g_{12e}	− 0.7	− 0.4	− 3.0	− 3.5	μmhos
g_{21e}	30	30	30	30	mmhos
b_{21e}	− 0.003	− 0.004	− 0.7	− 1.0	mmhos

FIGURE 1 — DC CURRENT GAIN

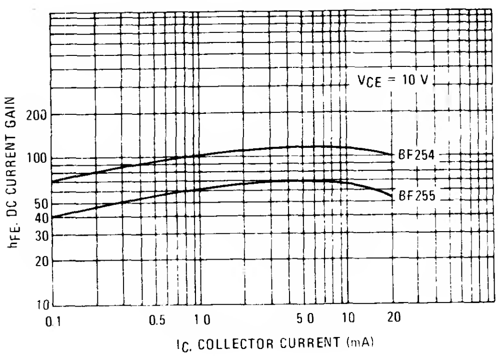


FIGURE 2 — CURRENT GAIN—BANDWITH PRODUCT

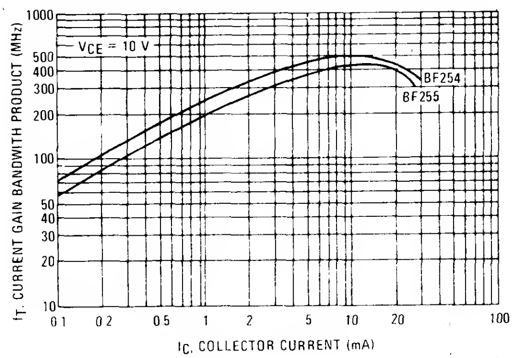


FIGURE 3 — "ON" VOLTAGE

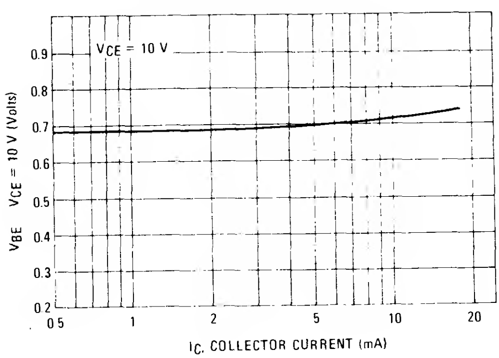
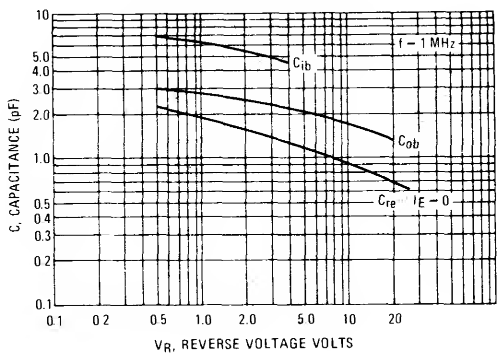


FIGURE 4 — CAPACITANCES



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BF366

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	25	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.B	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 B.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Collector Cutoff Current ($V_{CE} = 12$ Vdc, $I_B = 0$)	I_{CEO}	—	—	500	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 12$ mAdc, $V_{CE} = 7.0$ Vdc)	h_{FE}	 15 5.5	 — —	 — —	—
Base-Emitter On Voltage ($I_C = 12$ mAdc, $V_{CE} = 7.0$ Vdc)	$V_{BE(on)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain–Bandwidth Product ($I_C = 3.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	400	—	—	MHz
Feedback Capacitance (Common Emitter) ($V_{CE} = 10$ Vdc, f = 1 MHz)	C_{rb}	—	—	0.3	pF
Noise Figure ($I_C \approx 3.0$ mAdc, $V_{CB} \approx 10$ Vdc, $R_S = 50$ Ohms, f = 200 MHz)	N_f	—	—	3.5	dB
Common-Emitter Amplifier Power Gain ($I_C \approx 3.0$ mAdc, $V_{CB} \approx 10$ Vdc, $R_S = 50$ Ohms, f = 200 MHz)	G_{pb}	14	—	—	dB
Forward AGC Current (Gain Reduction = 30 dB, $V_{CB} = 10$ V, f = 200 MHz)	I_{AGC}	5	—	B	mAdc

2

BF367

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current − Continuous	I_C	25	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	27	35	200	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	1.5	3.0	Vdc
Base-Emitter On Voltage (I_C = 4 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.75	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain−Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	440	—	MHz
Feedback Capacitance (Common Emitter) (V_{CE} = 10 Vdc, I_E = 1 mA, f = 1.0 MHz)	C_{re}	—	0.2	0.22	pF
Noise Figure (Figure 3) ($I_E \approx$ 4.0 mAdc, $V_{CC} \approx$ 10 Vdc, V_{AGC} = 2.75 Vdc, R_S = 50 Ohms, f = 35 MHz)	N_f	—	3.0	—	dB
Common-Emitter Amplifier Power Gain (Figure 3) ($I_E \approx$ 4.0 mAdc, $V_{CC} \approx$ 12 Vdc, V_{AGC} = 2.75 Vdc, R_S = 50 Ohms, f = 35 MHz)	G_{pe}	—	25	—	dB
Forward AGC Voltage (Figure 3) (Gain Reduction = 30 dB, R_S = 50 Ohms, f = 35 MHz)	V_{AGC}	—	5.5	—	Vdc

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

TYPICAL ADMITTANCE PARAMETERS (V_{CE} = 10 Vdc, I_C = 4.0 mAdc, f = 35 MHz)

Input Conductance	g_{ie}	—	5.0	—	mmhos
Input Capacitance	C_{ie}	—	30	—	pF
Forward Transfer Admittance Magnitude	$\|Y_{fe}\|$	—	100	—	mmhos
Forward Transfer Admittance Phase Angle	$\varnothing_{fe}$	—	19	—	Degrees
Feedback Capacitance	C_{re}	—	0.2	—	pF
Output Conductance	g_{oe}	—	18	—	μmhos
Output Capacitance	C_{oe}	—	1.3	—	pF
Maximum Unilateralized Power Gain $G_{um} = \frac{\|Y_{fe}\|^2}{4\, g_{ie}\, g_{oe}}$	G_{um}	—	41	—	dB

V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 35 MHz, See Figure 3

FIGURE 1 – POWER GAIN

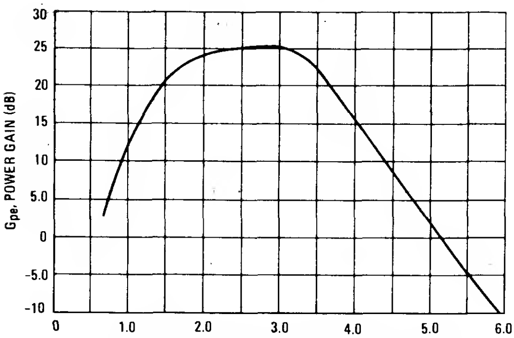


FIGURE 2 – NOISE FIGURE

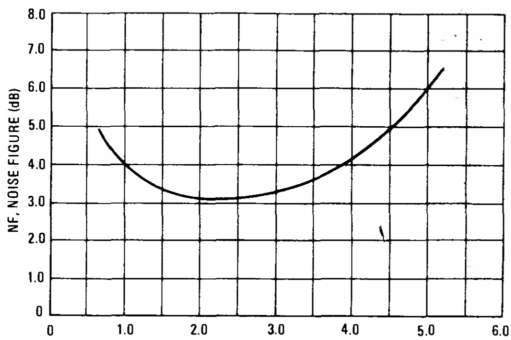
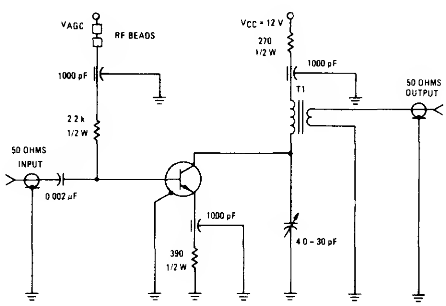


FIGURE 3 – 35 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



T_1 40/100 wire.
Primary 20 turns.
Secondary 3 turns.
Variable core.

BF371
BF373

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BF 371	BF 373	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	Vdc
Collector-Base Voltage	V_{CBO}	40	45	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current – Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BF371 BF373	$V_{(BR)CEO}$	30 45	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BF371 BF373	$V_{(BR)CBO}$	40 45	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 7.0 mAdc, V_{CE} = 10 Vdc) (I_C = 20 mAdc, V_{CE} = 2.0 Vdc)		h_{FE}	 40 15	 — —	 — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$	—	—	0.50	Vdc
Base-Emitter On Voltage (I_C = 7.0 mA, V_{CE} = 10 Vdc)		$V_{BE(on)}$	—	—	0.90	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain – Bandwidth Product (I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	BF371 BF373	f_T	400 500	720 720	—	MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}	—	0.20	0.32	pF

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BF374
BF375

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

VHF TRANSISTORS

NPN SILICON

Refer to MPSH10 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current − Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	25			Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	30			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.0			Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)		I_{CBO}			100	nAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)		I_{EBO}			100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	BF374 BF375 BF375C BF375D	h_{FE}	70 35 70 35		250 120 120 90	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$		50 70		mVdc mVdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$		830		mVdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc		$V_{BE(on)}$		700 770		mVdc mVdc
SMALL-SIGNAL CHARACTERISTICS						
Current Gain−Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	400	800		MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		0.55	0.6	pF
Collector-Base Time Constant (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 31.8 MHz)		r_bC_c		6		ps
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz, R_s = 50 ohms)		N_f		4		dB
Common-Emitter Amplifier Power Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)		G_{pe}		20		dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted)

TYPICAL ADMITTANCE PARAMETERS (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, frequency as stated)

Symbol	f = 10.7 MHz	f = 30 MHz	f = 100 MHz	Unit
G_{11e}	0.28	0.4	1.4	mmho
B_{11e}	0.6	1.6	5.0	mmho
G_{22e}	6.5	7	20	μmho
B_{22e}	0.1	0.3	1.0	mmho
G_{21e}	36	34	30	mmho
B_{21e}	− 0.8	− 2.5	− 9	mmho
B_{12e}	− 52	− 150	− 500	μmho

FIGURE 1 — INPUT ADMITTANCE
(Output short circuit)

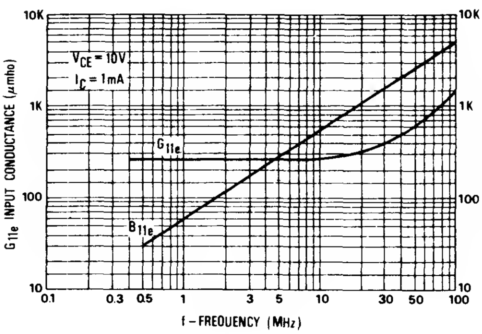


FIGURE 2 — OUTPUT ADMITTANCE
(Input short circuit)

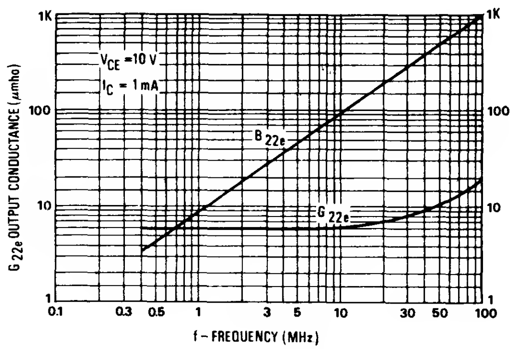


FIGURE 3 — FORWARD TRANSFER ADMITTANCE
(Output short circuit)

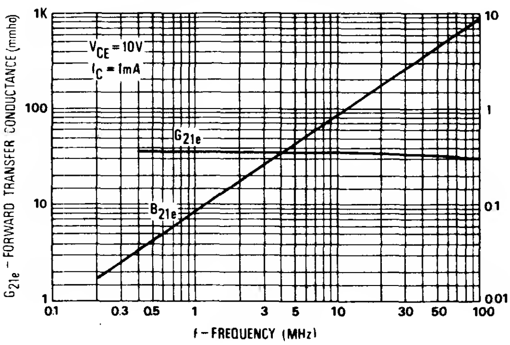
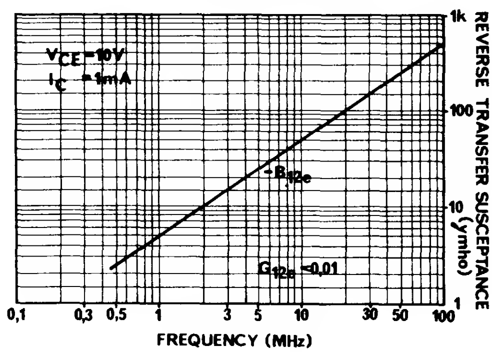


FIGURE 4 — REVERSE TRANSFER ADMITTANCE
(Input short circuit)



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BF391
BF392
BF393

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BF 391	BF 392	BF 393	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	300	Vdc
Collector-Base Voltage	V_{CBO}	200	250	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current – Continuous	I_C	500			mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BF391 BF392 BF393	$V_{(BR)CEO}$	200 250 300	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BF391 BF392 BF393	$V_{(BR)CBO}$	200 250 300	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BF391 BF392 BF393	$V_{(BR)EBO}$	6.0 6.0 6.0	— — —	Vdc
Collector Cutoff Current (V_{CB} = 160 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0)	BF391 BF392 BF393	I_{CBO}	— — —	0.1 0.1 0.1	μAdc
Emitter Cutoff Current (V_{CB} = 4.0 Vdc, I_C = 0) (V_{CB} = 6.0 Vdc, I_C = 0) (V_{CB} = 6.0 Vdc, I_C = 0)	BF391 BF392 BF393	I_{EBO}	— — —	0.1 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	All Types All Types	h_{FE}	25 40	— —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$		2.0	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mA, I_B = 2.0 mA)		$V_{BE(sat)}$		2.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	50	—	MHz
Common Emitter Feedback Capacitance (V_{CB} = 60 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		1.6	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

2

BF420
BF422

CASE 29-02, STYLE 14
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BF 420	BF 422	Unit
Collector-Emitter Voltage	V_{CEO}	300	250	Vdc
Collector-Base Voltage	V_{CBO}	300	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	800 6.4		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.75 22		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	45	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	156	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 1$ mAdc, $I_B = 0$)	BF420 BF422	$V_{(BR)CEO}$	300 250	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	BF420 BF422	$V_{(BR)CBO}$	300 250	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	BF420 BF422	$V_{(BR)EBO}$	5.0 5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$)	BF420 BF422	I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	BF420 BF422	I_{EBO}	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 25$ mAdc, $V_{CE} = 20$ Vdc)	BF420 BF422	h_{FE}	50 50	— —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$		0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mA, $I_B = 2.0$ mA)		$V_{BE(sat)}$		2.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 50 MHz)		f_T	60	—	MHz
Common Emitter Feedback Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{re}		2.8	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

2

BF421
BF423

CASE 29-02, STYLE 14
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BF 421	BF 423	Unit
Collector-Emitter Voltage	V_{CEO}	300	250	Vdc
Collector-Base Voltage	V_{CBO}	300	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	800 6.4		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.75 22		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	45	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	156	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_B = 0)	BF421 BF423	$V_{(BR)CEO}$	300 250	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BF421 BF423	$V_{(BR)CBO}$	300 250	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BF421 BF423	$V_{(BR)EBO}$	5.0 5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	BF421 BF423	I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	BF421 BF423	I_{EBO}	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 25 mA, V_{CE} = 20 Vdc)	BF421 BF423	h_{FE}	50 50	— —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$		0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mA, I_B = 2.0 mA)		$V_{BE(sat)}$		2.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 50 MHz)		f_T	60	—	MHz
Common Emitter Feedback Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		2.8	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

BF491
BF492
BF493

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	BF 491	BF 492	BF 493	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	300	Vdc
Collector-Base Voltage	V_{CBO}	200	250	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current − Continuous	I_C	500			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_B = 0)	 BF491 BF492 BF493	$V_{(BR)CEO}$	 200 250 300	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 BF491 BF492 BF493	$V_{(BR)CBO}$	 200 250 300	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	 BF491 BF492 BF493	$V_{(BR)EBO}$	 6.0 6.0 6.0	 — — —	Vdc
Collector Cutoff Current (V_{CB} = 160 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0)	 BF491 BF492 BF493	I_{CBO}	 — — —	 0.1 0.1 0.1	μAdc
Emitter Cutoff Current (V_{CB} = 4.0 Vdc, I_C = 0) (V_{CB} = 6.0 Vdc, I_C = 0) (V_{CB} = 6.0 Vdc, I_C = 0)	 BF491 BF492 BF493	I_{EBO}	 — — —	 0.1 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc), (I_C = 10 mAdc, V_{CE} = 10 Vdc)	 All Types All Types	h_{FE}	 25 40	 — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$		2.0	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mA, I_B = 2.0 mA)		$V_{BE(sat)}$		2.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain − Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	50	—	MHz
Common Emitter Feedback Capacitance (V_{CB} = 100 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		1.6	pF

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

2

BF493S

CASE 29-03, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to **MPSA93** for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	350	Vdc
Collector-Base Voltage	V_{CBO}	350	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	350	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 250$ Vdc)	I_{CES}	—	10	nAdc
Emitter Cutoff Current ($V_{BE} = 6$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 250$ Vdc, $I_E = 0$, $T_A = 25°C$) ($V_{CB} = 250$ Vdc, $I_E = 0$, $T_A = 100°C$)	I_{CBO}		0.005 1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	H_{FE}	25 40	— —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{CE(sat)}$		2.0	Vdc
Base-Emitter Voltage ($I_C = 20$ mA, $I_B = 2.0$ mA)	$V_{BE(sat)}$		2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)	f_T	50	—	MHz
Common Emitter Feedback Capacitance ($V_{CB} = 100$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{re}		1.6	pF

(1) Pulse Test: Pulse Width ≦ 300 μS — Duty Cycle ≦ 2%.

BF494
BF495

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SILICON

Refer to BF254 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current − Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	20			Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	30			Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0			Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}			100	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}			100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mA, V_{CE} = 10 Vdc)	BF494	h_{FE}	65		220	
	BF494A		65		125	
	BF494B		125		220	
	BF495		35		125	
	BF495A		35		75	
	BF495B		65		125	
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$			0.74	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current Gain−Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	150			MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{re}		0.90		pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1 MHz, R_S = 50 ohms)		N_f		1.7		dB

TYPICAL ADMITTANCE PARAMETERS (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, frequency as stated)

Symbol	f = 450 KHz		f = 10.7 MHz		Unit
	BF494	BF495	BF494	BF495	
g_{11e}	0.20	0.40	0.26	0.5	mmhos
b_{11e}	0.05	0.06	1.2	1.6	mmhos
g_{22e}	3.0	1.5	5.3	4.5	μmhos
b_{22e}	8.0	8.0	190	190	μmhos
b_{12e}	− 5.0	− 5.0	− 130	− 130	μmhos
g_{12e}	− 0.7	− 0.4	− 3.0	− 3.5	μmhos
g_{21e}	30	30	30	30	mmhos
b_{21e}	− 0.003	− 0.004	− 0.7	− 1.0	mmhos

2

BF506

CASE 29-03, STYLE 17
TO-92 (TO-226AA)

VHF TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

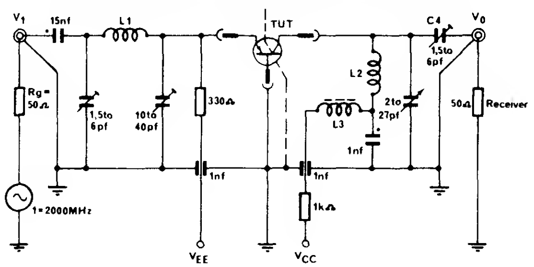
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	35	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 V, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	—	
SMALL SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	600	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{CBO}	—	0.6	0.9	pF
Feedback Capacitance (Grounded Base) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{rb}	—	0.15	0.25	pF
Noise Figure (I_C = 1 mA, R_S = 50 Ω, f = 200 MHz, V_{CC} = 6 V)	N_F	—	2.5	4	dB
Power Gain (I_C = 3 mA, R_L = 1 KΩ, f = 200 MHz, V_{CC} = 10.8 V)	G_{pb}	14	22	—	dB

200 MHz POWER GAIN NOISE FIGURE TEST CIRCUIT



* Leadless ceramic disc capacitor
L1 – 3 turns 0.0 mm enamel, 4 mm dia
L2 – 2 turns 1 mm enamel, 6.5 mm dia

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FIGURE 1 – CURRENT GAIN – BANDWIDTH PRODUCT

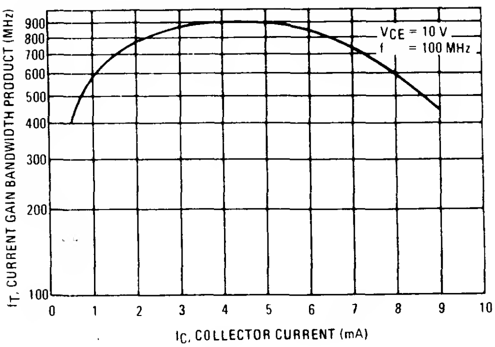


FIGURE 2 – NOISE FIGURE

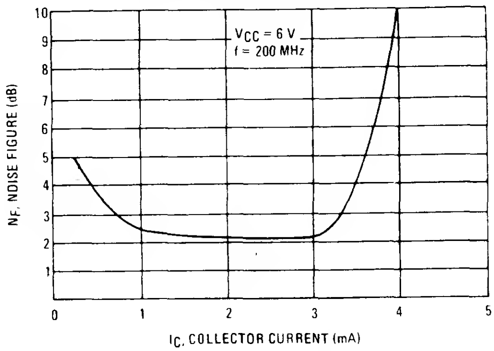


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

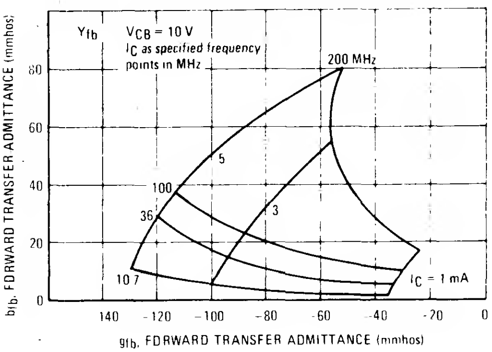


FIGURE 4 – INPUT ADMITTANCE

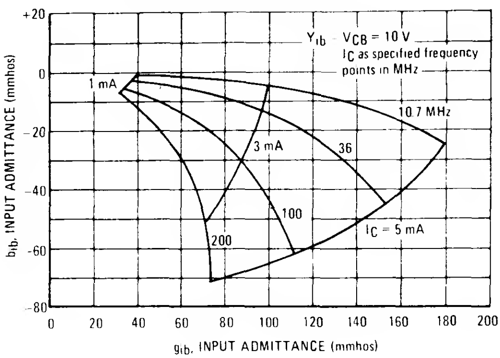
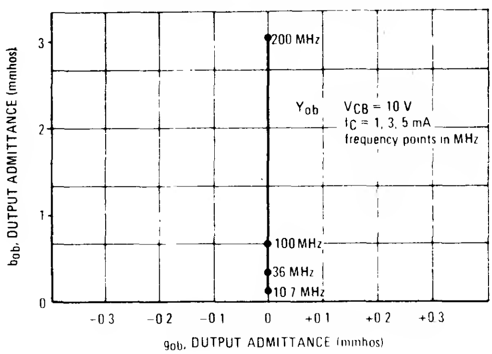


FIGURE 5 – OUTPUT ADMITTANCE



BF509

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

VHF TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

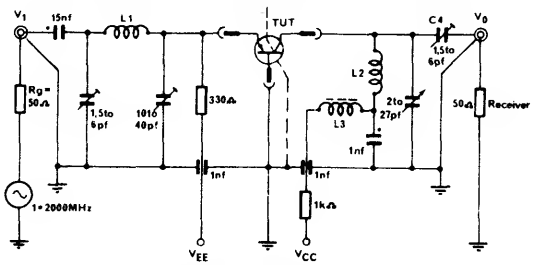
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	35	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 V, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	—	
SMALL SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 3 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	850	—	MHz
Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{rb}	—	0.15	0.25	pF
Collector-Base Capacitance (V_{CB} = 10 V, I_E = 0, f = 1.0 MHz)	C_{CBO} (C_{re})	—	0.6	0.9	pF
Noise Figure (I_C = 3 mAdc, V_{CC} = 10.8 V, R_S = 50 Ohms, f = 200 MHz)	N_F	—	—	2.5	dB
Common-Base Amplifier Power Gain (I_C = 3 mAdc, V_{CC} = 10.8 V, R_L = 1 KΩ, f = 200 MHz)	G_{pb}	15	22	—	dB
Forward AGC Current ($I_{C(Agc)}$ (Gain Reduction = 30 dB, R_S = 50 Ohms, V_{CC} = 10.8 V, f = 200 MHz)	$I_{C(Agc)}$	7	—	8.8	mAdc

200 MHz POWER GAIN NOISE FIGURE TEST CIRCUIT



* Leadless ceramic disc capacitor
L1 = 3 turns 0.0 mm enamel, 4 mm dia
L2 = 2 turns 1 mm enamel, 6.5 mm dia

FIGURE 1 — DC CURRENT GAIN

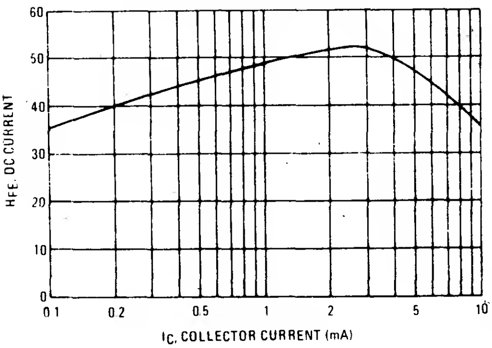


FIGURE 2 — CURRENT GAIN — BANDWIDTH PRODUCT

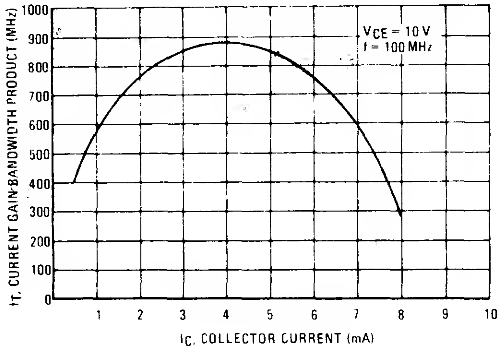


FIGURE 3 — CAPACITANCES

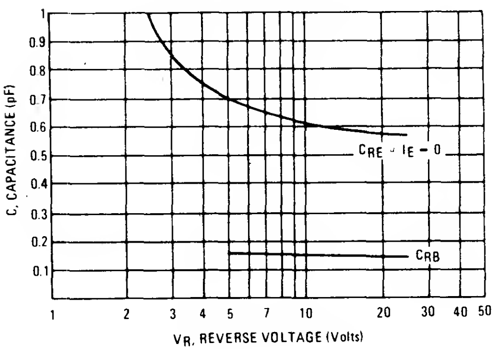


FIGURE 4 — TYPICAL POWER GAIN

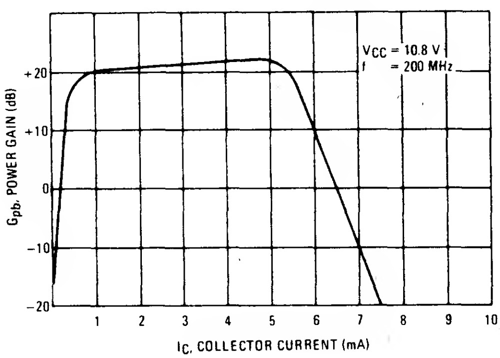


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

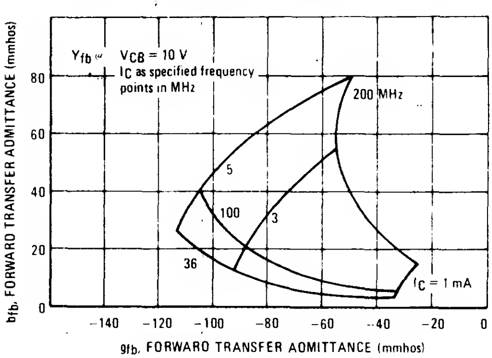
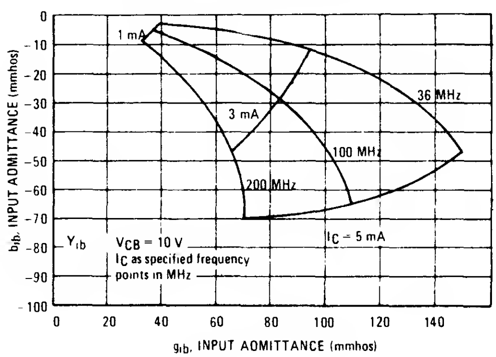


FIGURE 6 — INPUT ADMITTANCE



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BF844
BF845

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA44 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BF 844	BF 845	Unit
Collector-Emitter Voltage	V_{CEO}	400	350	Vdc
Collector-Base Voltage	V_{CBO}	450	400	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current − Continuous	I_C	300		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 BF844 BF845	$V_{(BR)CEO}$	 400 350	 — —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	 BF844 BF845	$V_{(BR)CES}$	 450 400	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 BF844 BF845	$V_{(BR)CBO}$	 450 400	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	Both Types	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 400 Vdc, I_E = 0) (V_{CB} = 320 Vdc, I_E = 0)	 BF844 BF845	I_{CBO}	 — —	 0.1 0.1	μAdc
Collector Cutoff Current (V_{CE} = 400 Vdc, V_{BE} = 0) (V_{CE} = 320 Vdc, V_{BE} = 0)	 BF844 BF845	I_{CES}	 — —	 500 500	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	Both Types	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc) (I_C = 100 mAdc, V_{CE} = 10 Vdc)	 Both Types Both Types Both Types Both Types	h_{FE}	 40 50 45 20	 — 200 — —	—
Collector-Emitter Saturation Voltage (1) (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types Both Types Both Types	$V_{CE(sat)}$	 — — —	 0.4 0.5 0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.75	Vdc

(1) Pulse Test: Pulse Width ≦ 300 μS — Duty Cycle ≦ 2.0%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS					
High Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)	Both Types	$\|h_{fe}\|$	2.0	—	
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	Both Types	C_{ob}	—	6.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	Both Types	C_{ib}	—	110	pF
Turn-On Time (V_{CC} = 150 Vdc, $V_{BE(off)}$ = 4.0 V, I_C = 30 mAdc, I_{B1} = 3.0 mAdc)	Both Types	t_{on}	—	0.6	µs
Turn-Off Time (V_{CC} = 150 Vdc, I_C = 30 mAdc, I_{B1} = I_{B2} = 3.0 mAdc)	Both Types	t_{off}	—	10	µs

FIGURE 1 — DC CURRENT GAIN

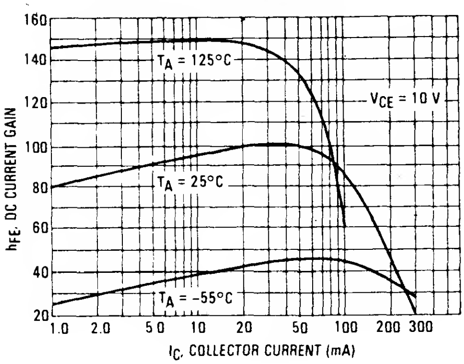
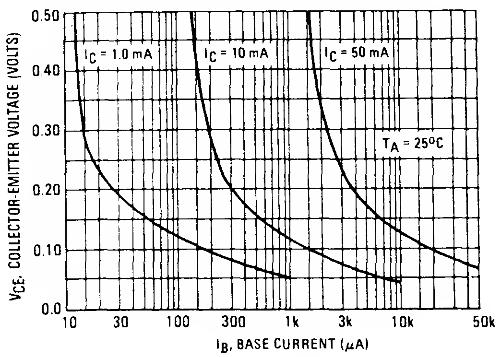


FIGURE 2 — COLLECTOR SATURATION REGION



2

BF959

CASE 29-02, STYLE 21
TO-92 (TO-226AA)

VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current − Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5 mAdc, V_{CE} = 10 Vdc) (I_C = 20 mAdc, V_{CE} = 10 Vdc)	h_{FE}	35 40	— —	— —	
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	—	—	1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain − Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_t	700 600	— —	— —	MHz
Common Emitter Feedback Capacitance (V_{CB} = 10 Vdc, P_f = 0, f = 10 MHz)	C_{re}	—	0.65	—	pF
Noise Figure (I_C = 4 mA, V_{CE} = 10 V, R_S = 50 Ω, f = 200 MHz)	N_f	—	3	—	dB

FIGURE 1 – Hfe AT 10 V

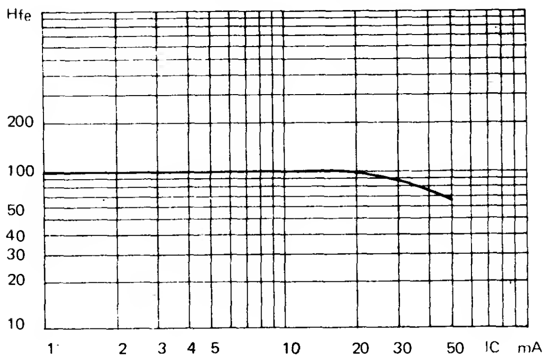


FIGURE 2 – VCE Sat AT IC/IB = 10

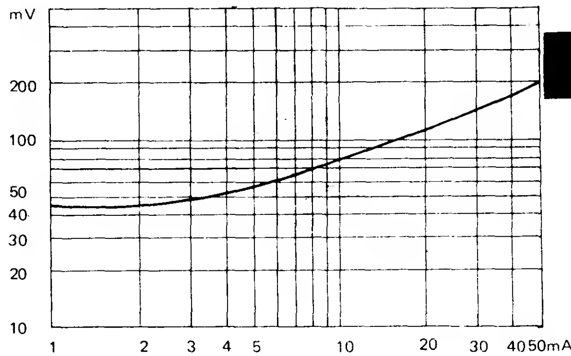


FIGURE 3 – CURRENT-GAIN – BANDWIDTH-PRODUCT

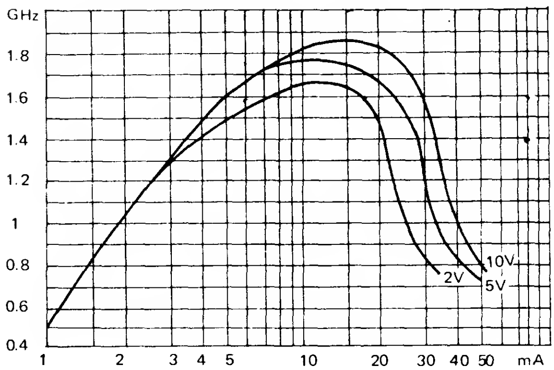


FIGURE 4 – CAPACITANCES

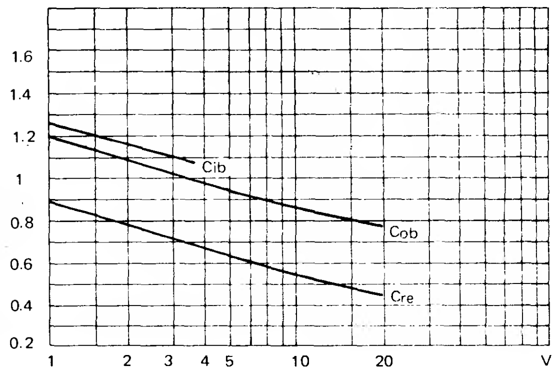


FIGURE 5 – INPUT IMPEDANCE AT 30 MHz

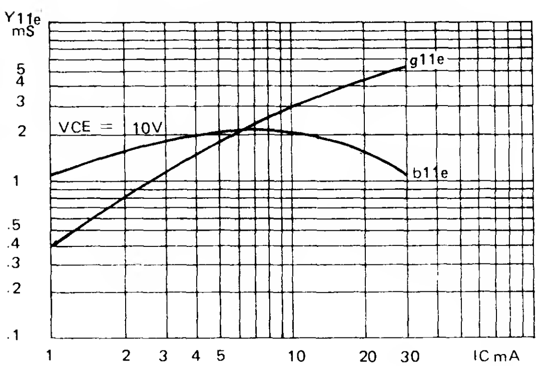
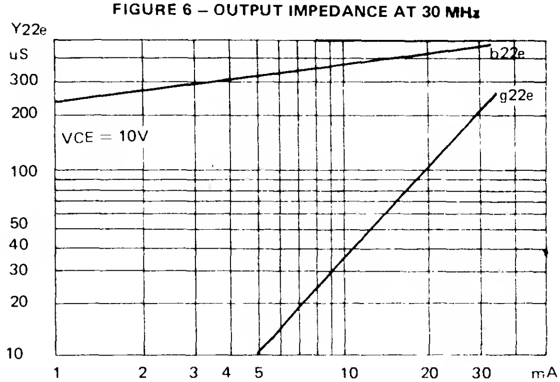


FIGURE 6 – OUTPUT IMPEDANCE AT 30 MHz



2

MPS404
MPS404A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

CHOPPER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS404	MPS404A	Unit
Collector-Emitter Voltage	V_{CEO}	24	35	Vdc
Collector-Base Voltage	V_{CBO}	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	25	Vdc
Collector Current — Continuous	I_C	150		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	MPS404 MPS404A	$V_{(BR)CEO}$	24 35	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS404 MPS404A	$V_{(BR)CBO}$	25 40	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MPS404 MPS404A	$V_{(BR)EBO}$	12 25	50 50	— —	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 12 mAdc, V_{CE} = 0.15 Vdc)		h_{FE}	30	100	400	—
Collector-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc) (I_C = 24 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	— —	0.1 0.12	0.15 0.20	Vdc
Base-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc) (I_C = 24 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	— —	0.7 0.74	0.85 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Common-Base Cutoff Frequency (I_C = 1.0 mAdc, V_{CB} = 6.0 Vdc)		f_{ob}	4.0	—	—	MHz
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.8	20	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – COLLECTOR-EMITTER VOLTAGE

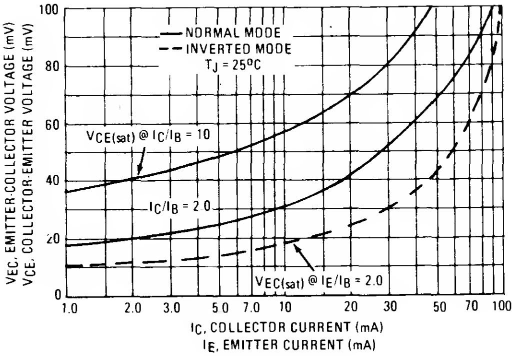
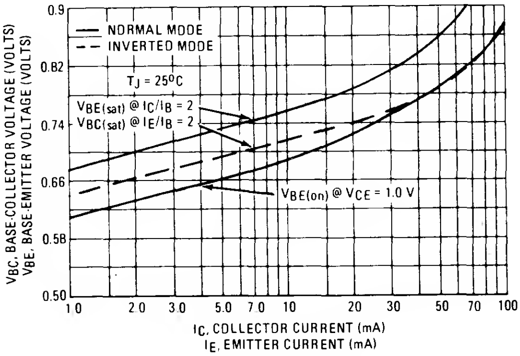


FIGURE 2 – BASE "ON" VOLTAGE



2

NORMAL MODE

FIGURE 3 – DC CURRENT GAIN @ V_{CE} = 0.15 Vdc

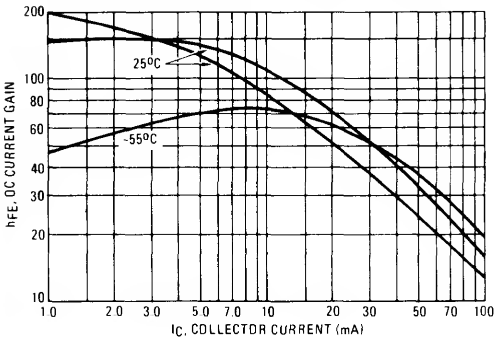
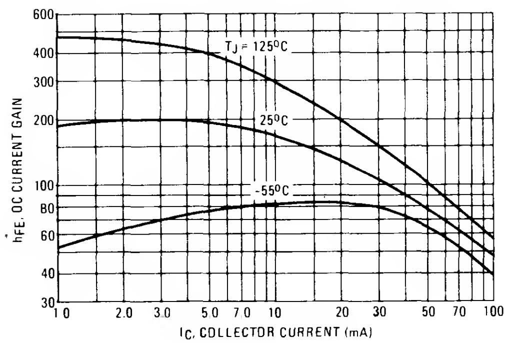


FIGURE 5 – DC CURRENT GAIN @ V_{CE} = 1.0 Vdc



INVERTED MODE

FIGURE 4 – DC CURRENT GAIN @ V_{EC} = 0.15 Vdc

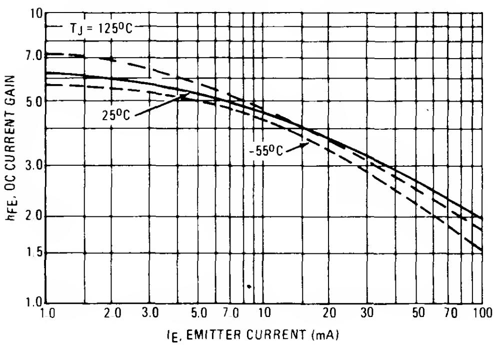


FIGURE 6 – DC CURRENT GAIN @ V_{EC} = 1.0 Vdc

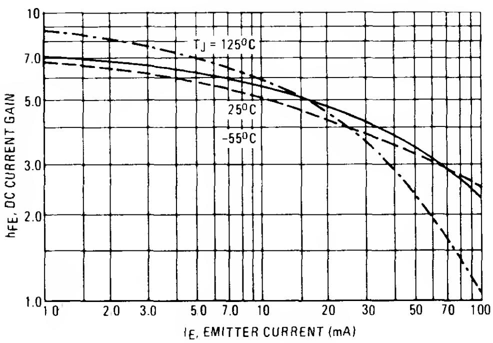


FIGURE 7 – COLLECTOR SATURATION REGION

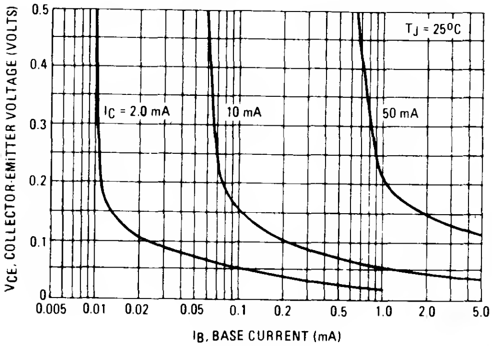


FIGURE 8 – EMITTER SATURATION REGION

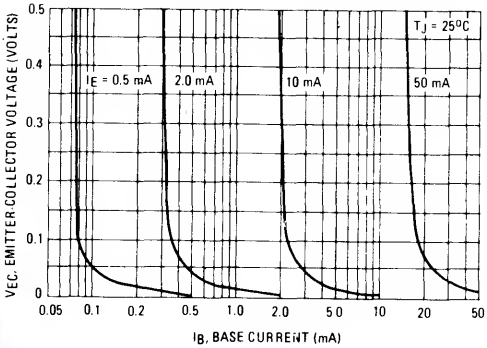


FIGURE 9 – EMITTER-COLLECTOR "ON" RESISTANCE

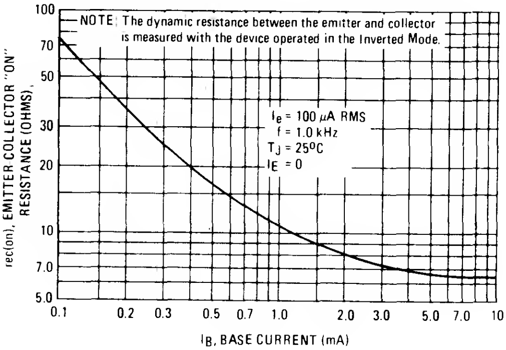


FIGURE 10 – CAPACITANCE

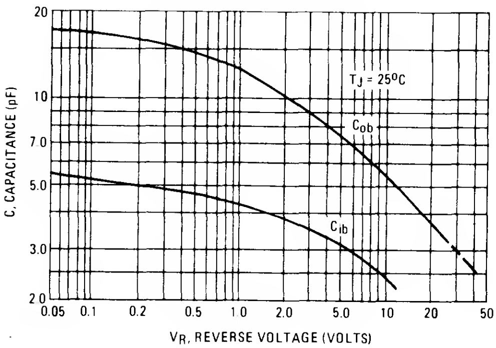


FIGURE 11 – TURN-ON TIME

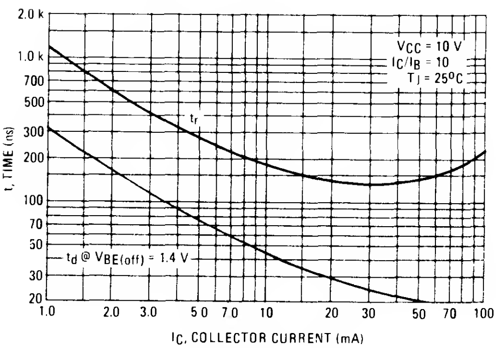


FIGURE 12 – TURN-OFF TIME

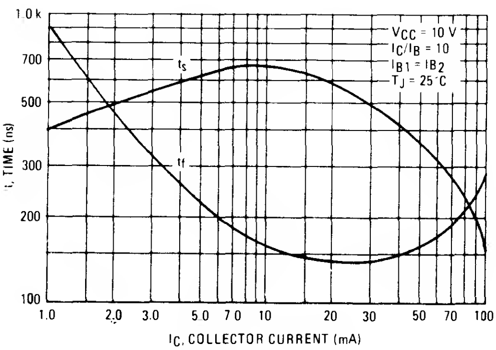
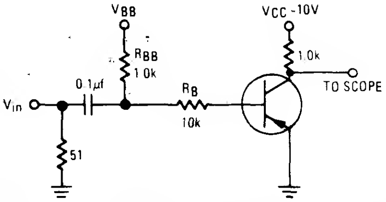


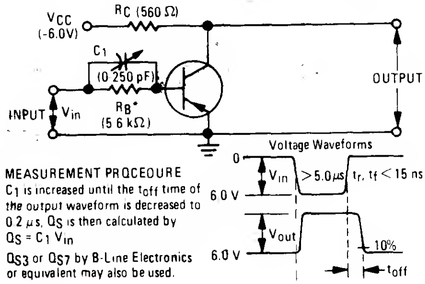
FIGURE 13 – SWITCHING TIME TEST CIRCUIT



	Vin (Volts)	VBB (Volts)
t_{on}, t_d and t_r	-12	+1.4
t_{off}, t_s and t_f	+20.6	-11.6

Voltages and resistor values shown are for I_C = 10 mA, I_C/I_B = 10 and $I_{B1} = I_{B2}$. Resistor values changed to obtain curves in Figures 11 and 12.

FIGURE 14 – STORED BASE CHARGE TEST CIRCUIT



MEASUREMENT PROCEDURE

C_1 is increased until the t_{off} time of the output waveform is decreased to 0.2 µs. Q_S is then calculated by $Q_S = C_1 V_{in}$

QS3 or QS7 by B-Line Electronics or equivalent may also be used.

2

MPS650
MPS651
NPN SILICON

MPS750
MPS751
PNP SILICON

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	MPS650 MPS750	MPS651 MPS751	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 MPS650, MPS750 MPS651, MPS751	$V_{(BR)CEO}$	 40 60	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	 MPS650, MPS750 MPS651, MPS751	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MPS650, MPS750 MPS651, MPS751	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ V, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 50$ mA, $V_{CE} = 2.0$ V) ($I_C = 500$ mA, $V_{CE} = 2.0$ V) ($I_C = 1.0$ A, $V_{CE} = 2.0$ V) ($I_C = 2.0$ A, $V_{CE} = 2.0$ V)		h_{FE}	 75 75 75 40	 — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 2.0$ A, $I_B = 200$ mA) ($I_C = 1.0$ A, $I_B = 100$ mA)		$V_{CE(sat)}$	 — —	 0.5 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0$ A, $I_B = 100$ mA)		$V_{BE(sat)}$	—	1.2	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ A, $V_{CE} = 2.0$ V)		$V_{BE(on)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	75	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MPS918
MPS3563

CASE 29-02, STYLE 1
TO-92 (TO-226AA)
AMPLIFIER TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPS918	MPS3563	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CBO}	30	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	2.0	Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 3.0 mAdc, I_B = 0)	MPS918 MPS3563	$V_{(BR)CEO}$	15 12	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0) (I_C = 100 μAdc, I_E = 0)	MPS918 MPS3563	$V_{(BR)CBO}$	30 30	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MPS918 MPS3563	$V_{(BR)EBO}$	3.0 2.0	— —	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	MPS918 MPS3563	I_{CBO}	— —	10 50	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	MPS918	h_{FE}	20 20	— 200	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS918	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS918	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS918 MPS3563	f_T	600 600	— 1500	MHz
Output Capacitance (V_{CB} = 0 Vdc, I_E = 0, f = 140 kHz) (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MPS918 MPS918 MPS3563	C_{obo}	— — —	3.0 1.7 1.7	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	MPS918	C_{ibo}	—	2.0	pF
Small-Signal Current Gain (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3563	h_{fe}	20	250	—
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 ohms, f = 60 MHz)	MPS918	NF	—	6.0	dB

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (I_C = 6.0 mAdc, V_{CB} = 12 Vdc, f = 200 MHz) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz) (G_{fd} + G_{re} < −20 dB)	 MPS918 MPS3563	G_{pe}	 15 14	 — —	dB
Power Output (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, f = 500 MHz)	MPS918	P_{out}	30	—	mW
Oscillator Collector Efficiency (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, P_{out} = 30 mW, f = 500 MHz)	MPS918	η	25	—	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MPS2222
MPS2222A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPS2222	MPS2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS2222 MPS2222A	$V_{(BR)CEO}$	30 40	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS2222 MPS2222A	$V_{(BR)CBO}$	60 75	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MPS2222 MPS2222A	$V_{(BR)EBO}$	5.0 6.0	— —	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MPS2222A	I_{CEX}	—	10	nAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C) (V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C)	MPS2222 MPS2222A MPS2222 MPS2222A	I_{CBO}	— — — —	0.01 0.01 10 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	MPS2222A	I_{EBO}	—	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MPS2222A	I_{BL}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	 MPS2222A only MPS2222 MPS2222A	h_{FE}	 35 50 75 35 100 50 30 40	 — — — — 300 — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 MPS2222 MPS2222A MPS2222 MPS2222A	$V_{CE(sat)}$	 — — — —	 0.4 0.3 1.6 1.0	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MPS2222		—	1.3	
	MPS2222A		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	MPS2222		—	2.6	
	MPS2222A		—	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MPS2222		250	—	
	MPS2222A		300	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS2222		—	30	
	MPS2222A		—	25	
Input Impedance		h_{ie}			kΩ
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		0.25	1.25	
Voltage Feedback Ratio		h_{re}			$X\ 10^{-4}$
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A		25	200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	MPS2222A	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	MPS2222A	NF	4.0	4.0	dB

SWITCHING CHARACTERISTICS MPS2222A only

		Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON TIME

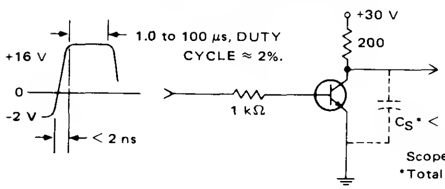
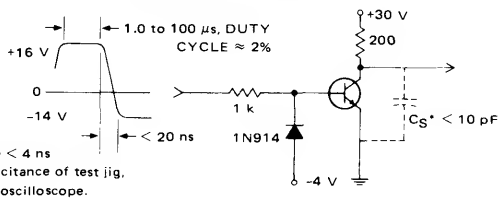


FIGURE 2 – TURN-OFF TIME



Scope Rise Time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope.

FIGURE 3 – DC CURRENT GAIN

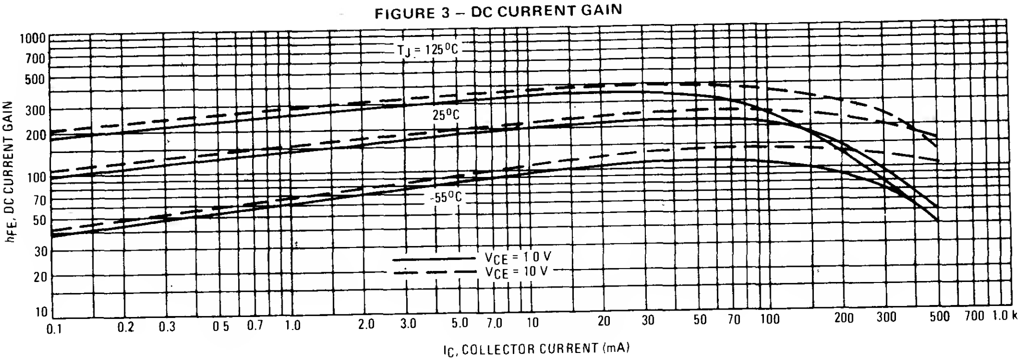


FIGURE 4 – COLLECTOR SATURATION REGION

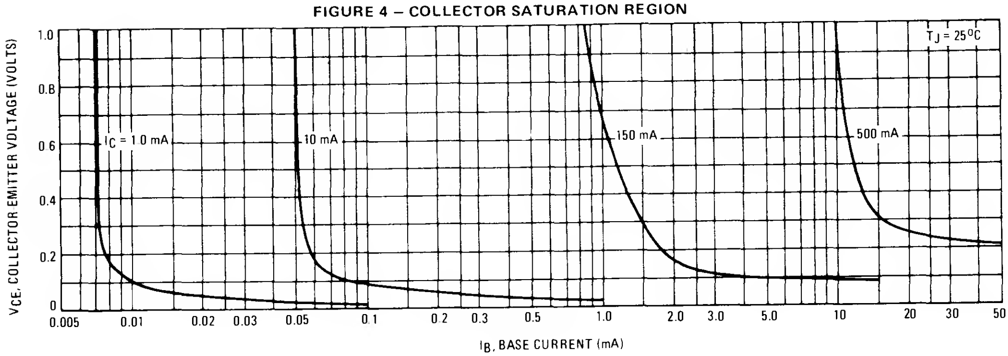


FIGURE 5 – TURN-ON TIME

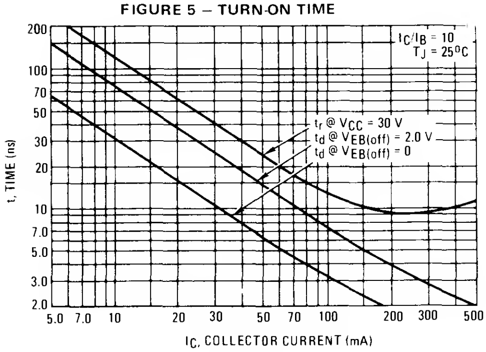


FIGURE 6 – TURN-OFF TIME

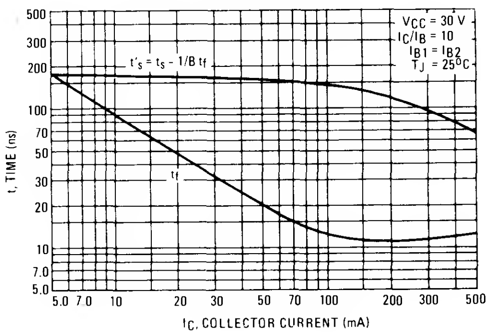


FIGURE 7 – FREQUENCY EFFECTS

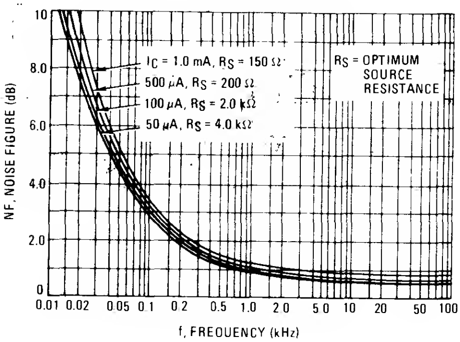


FIGURE 8 – SOURCE RESISTANCE EFFECTS

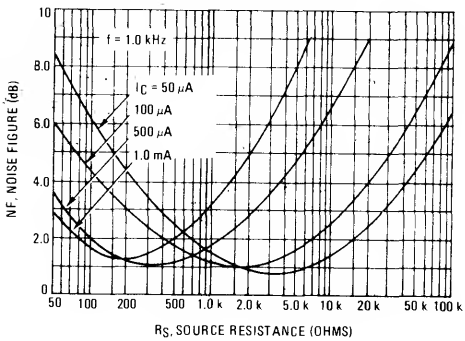


FIGURE 9 – CAPACITANCES

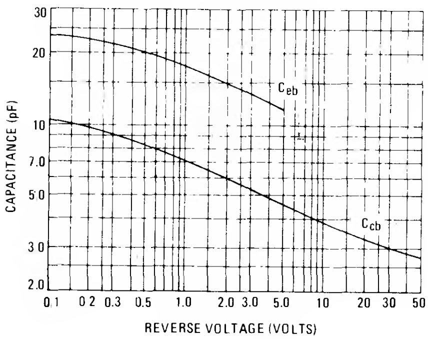


FIGURE 10 – CURRENT-GAIN BANDWIDTH PRODUCT

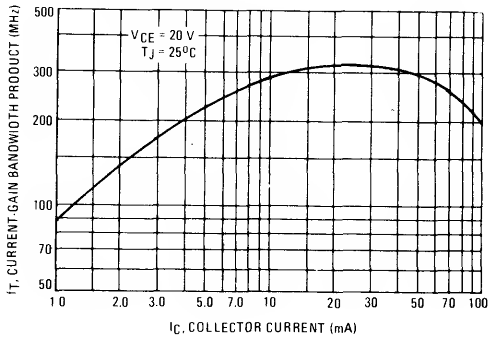


FIGURE 11 – "ON" VOLTAGES

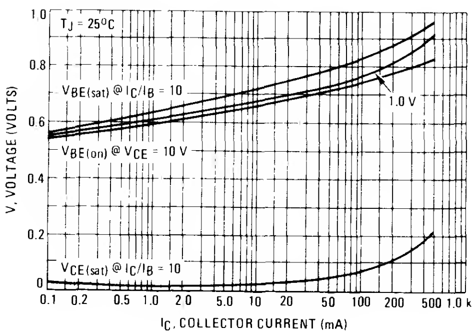
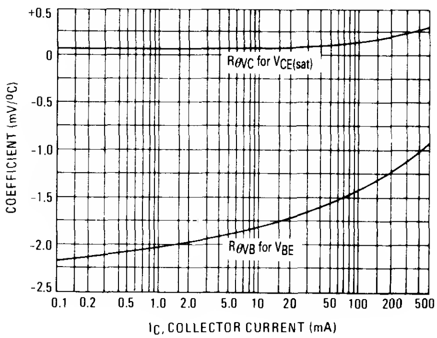


FIGURE 12 – TEMPERATURE COEFFICIENTS



MPS2369

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	 — —	 — —	 0.4 30	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 20 20	 — — —	 120 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.70	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	5.0	—	—	—
SWITCHING CHARACTERISTICS					
Storage Time (I_{B1} = I_{B2} = I_C = 10 mAdc) (Figure 3)	t_s	—	5.0	13	ns
Turn-On Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc) (Figure 1)	t_{on}	—	8.0	12	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc) (Figure 2)	t_{off}	—	10	18	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

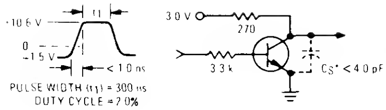


FIGURE 1 – t_{on} CIRCUIT

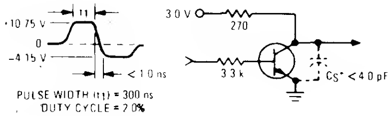


FIGURE 2 – t_{off} CIRCUIT

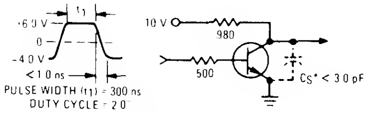


FIGURE 3 – STORAGE TEST CIRCUIT

*Total shunt capacitance of test jig and connectors

2

MPS2907
MPS2907A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS2907	MPS2907A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 MPS2907 MPS2907A	$V_{(BR)CEO}$	 40 60	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc)		I_{CEX}	—	50	nAdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 125°C$)	 MPS2907 MPS2907A MPS2907 MPS2907A	I_{CBO}	 — — — —	 0.020 0.010 20 10	μAdc
Base Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc)		I_B	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1)	 MPS2907 MPS2907A MPS2907 MPS2907A MPS2907 MPS2907A MPS2907, MPS2907A MPS2907 MPS2907A	h_{FE}	 35 75 50 100 75 100 100 30 50	 — — — — — — 300 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	 — —	 0.4 1.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	 — —	 1.3 2.6	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1),(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figures 1 and 5)	t_{on}	—	45	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_{off}	—	100	ns
Storage Time		t_s	—	80	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – DELAY AND RISE TIME TEST CIRCUIT

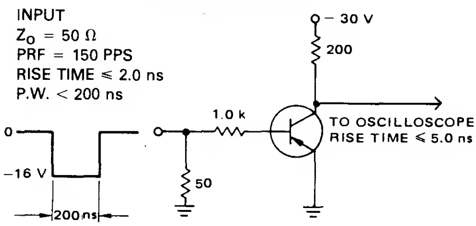
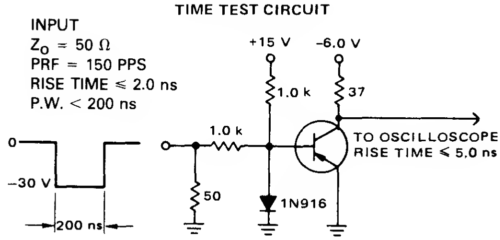


FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT



TYPICAL CHARACTERISTICS

FIGURE 3 – DC CURRENT GAIN

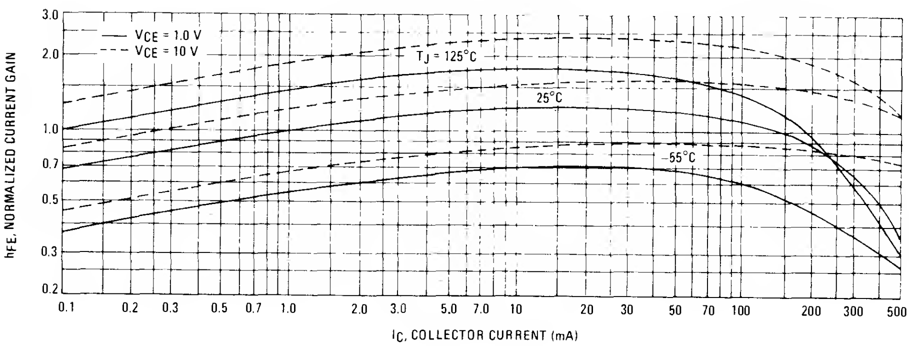


FIGURE 4 — COLLECTOR SATURATION REGION

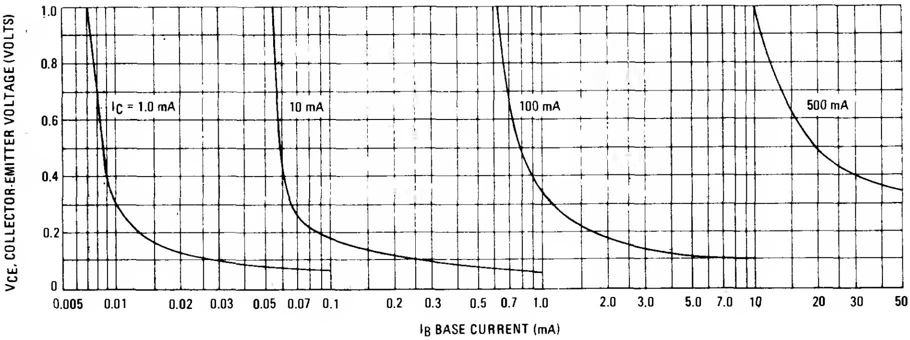


FIGURE 5 — TURN-ON TIME

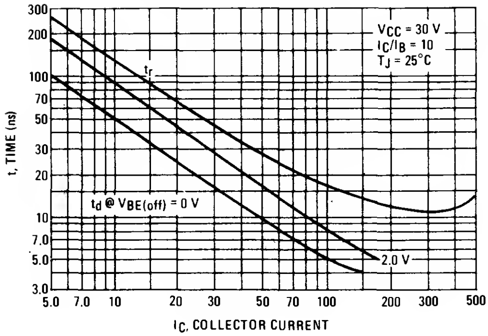
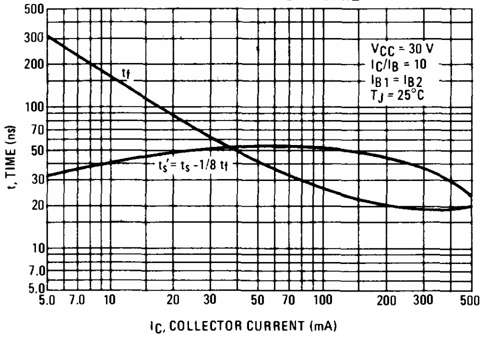


FIGURE 6 — TURN-OFF TIME



TYPICAL SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE
V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 7 — FREQUENCY EFFECTS

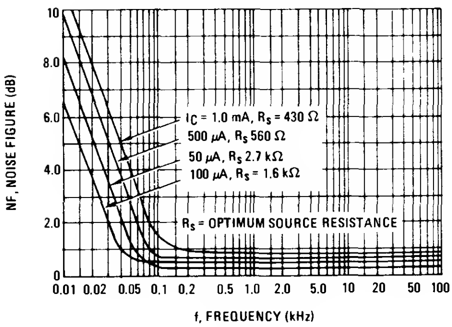


FIGURE 8 — SOURCE RESISTANCE EFFECTS

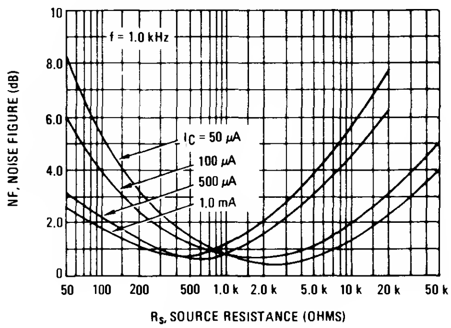


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FIGURE 9 – CAPACITANCES

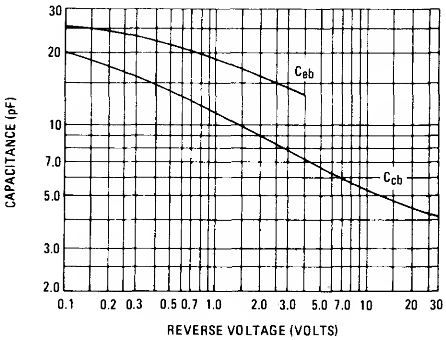


FIGURE 10 – CURRENT-GAIN – BANDWIDTH PRODUCT

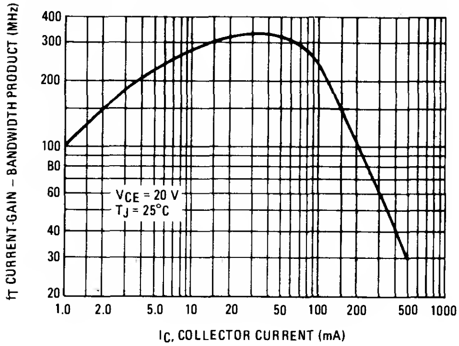


FIGURE 11 – "ON" VOLTAGE

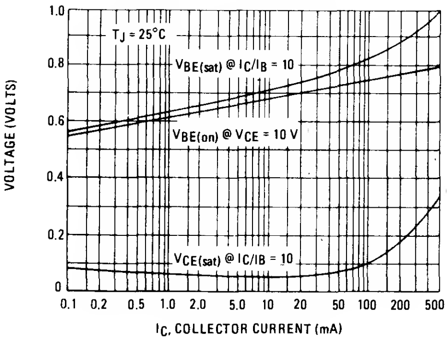
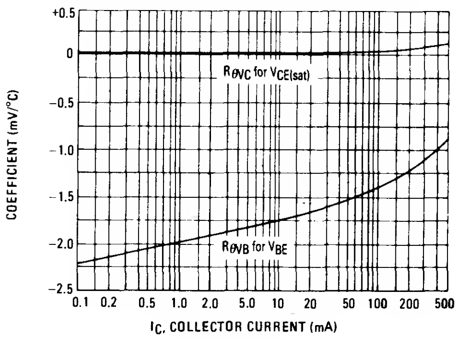


FIGURE 12 – TEMPERATURE COEFFICIENTS



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MPS3638
MPS3638A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	40	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)		$V_{(BR)CES}$	25	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{CEO(sus)}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)		$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$) ($V_{CE} = 15$ Vdc, $V_{BE} = 0$, $T_A = -65°C$)		I_{CES}	 — —	 0.035 2.0	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ V, $I_C = 0$)		I_{EBO}	—	35	nA
Base Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$)		I_B	—	0.035	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	 MPS3638A	h_{FE}	 80	 —	—
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	MPS3638 MPS3638A		20 100	— —	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3638 MPS3638A		30 100	— —	
($I_C = 300$ mAdc, $V_{CE} = 2.0$ Vdc)	MPS3638 MPS3638A		20 20	— —	
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 2.5$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)		$V_{CE(sat)}$	 — —	 0.25 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 2.5$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)		$V_{BE(sat)}$	 — 0.80	 1.1 2.0	Vdc

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ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 3.0 Vdc, I_C = 50 mAdc, f = 100 MHz)	MPS3638 MPS3638A	f_T	100 150	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MPS3638 MPS3638A	C_{obo}	— —	20 10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS3638 MPS3638A	C_{ibo}	— —	65 25	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	—	2000	Ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638 MPS3638A	h_{re}	— —	26 15	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638 MPS3638A	h_{fe}	25 100	— —	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	—	1.2	mmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = 30 mAdc)	t_d	—	20	ns
Rise Time		t_r	—	70	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = 30 mAdc, I_{B2} = 30 mAdc)	t_s	—	140	ns
Fall Time		t_f	—	70	ns
Turn-On Time	(I_C = 300 mAdc, I_{B1} = 30 mAdc)	t_{on}	—	75	ns
Turn-Off Time	(I_C = 300 mAdc, I_{B1} = 30 mAdc, I_{B2} = 30 mAdc)	t_{off}	—	170	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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MPS3640

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	80	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

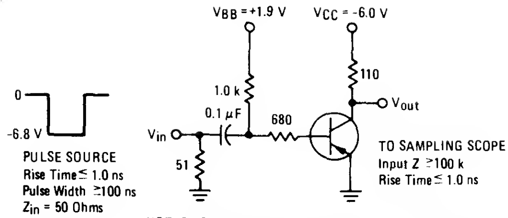
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0) (V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	— —	0.01 1.0	μAdc
Base Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)	I_B	—	10	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 20	120 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 65°C)	$V_{CE(sat)}$	— — —	0.2 0.6 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	0.75 0.8 —	0.95 1.0 1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 Vdc, I_{B1} = 5.0 mAdc)	t_d	—	10	ns
Rise Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 Vdc, I_{B1} = 5.0 mAdc)	t_r	—	30	ns
Storage Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	t_s	—	20	ns
Fall Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	t_f	—	12	ns
Turn-On Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 Vdc, I_{B1} = 5.0 mAdc) (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 0.5 mAdc)	t_{on}	 — —	 25 60	ns
Turn-Off Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 V, I_{B1} = I_{B2} = 5.0 mAdc) (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 0.5 mAdc)	t_{off}	 — —	 35 75	ns

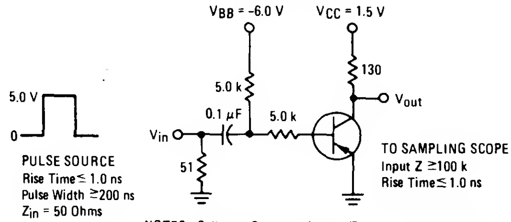
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1



NOTES: Collector Current = 50 mA, Turn-On and Turn-Off Time Base Currents = 5.0 mA.

FIGURE 2



NOTES: Collector Current = 10 mA, Turn-On and Turn-Off Time Base Currents = 0.5 mA.

FIGURE 3 – DC CURRENT GAIN

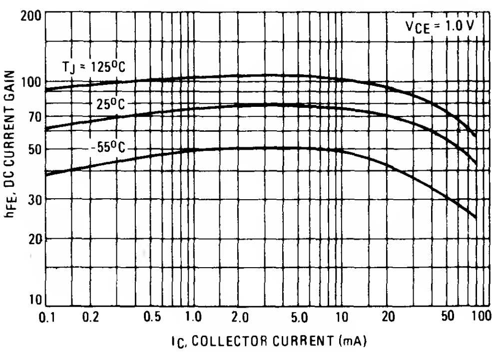


FIGURE 4 – "ON" VOLTAGES

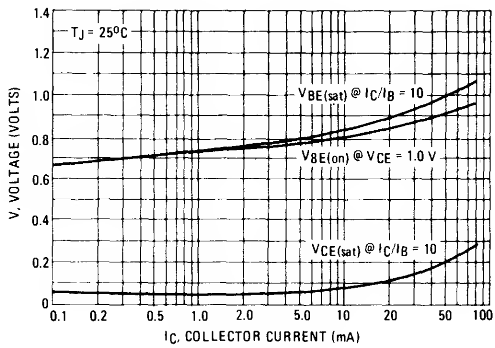


FIGURE 5 – COLLECTOR SATURATION REGION

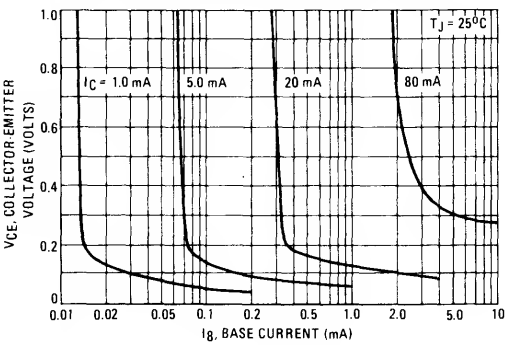


FIGURE 6 – TEMPERATURE COEFFICIENTS

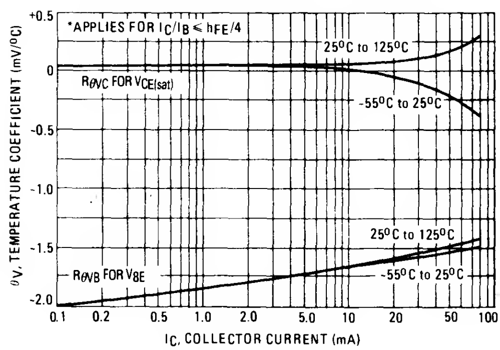


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

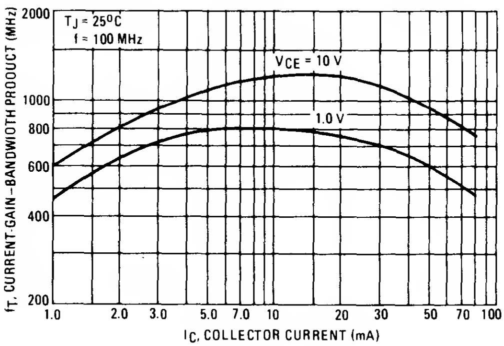
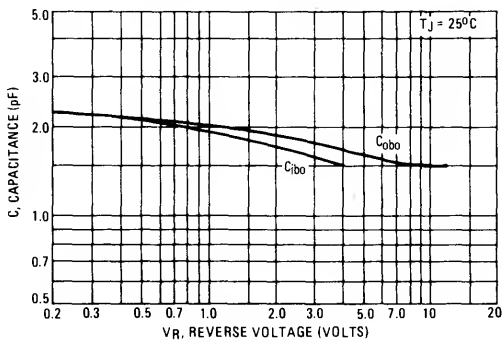


FIGURE 8 – CAPACITANCE



MPS3646

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N4264 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous — 10 μs Pulse	I_C	300 500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	40	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$) ($V_{CE} = 20$ Vdc, $V_{BE} = 0$, $T_A = 65°C$)	I_{CES}	— —	0.5 3.0	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 30$ mAdc, $V_{CE} = 0.4$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 0.5$ Vdc) ($I_C = 300$ mA, $V_{CE} = 1.0$ Vdc)	h_{FE}	30 25 15	120 — —	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc) ($I_C = 30$ mA, $I_B = 3.0$ mA, $T_A = 65°C$)	$V_{CE(sat)}$	— — — —	0.2 0.28 0.5 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mA)	$V_{BE(sat)}$	0.73 — —	0.95 1.2 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	350	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	5.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	—	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Time	($V_{CC} = 10$ Vdc, $V_{BE(off)} = 3.0$ Vdc, $I_C = 300$ mAdc, $I_{B1} = 30$ mAdc) (Figure 1)	t_{on}	—	18	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	15	ns
Turn-Off Time	($V_{CC} = 10$ Vdc, $I_C = 300$ mAdc, $I_{B1} = I_{B2} = 30$ mAdc) (Figure 1)	t_{off}	—	28	ns
Fall Time		t_f	—	15	ns
Storage Time	($V_{CC} = 10$ Vdc, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 10$ mAdc) (Figure 2)	t_s	—	18	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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FIGURE 1 – SWITCHING TIME TEST CIRCUIT

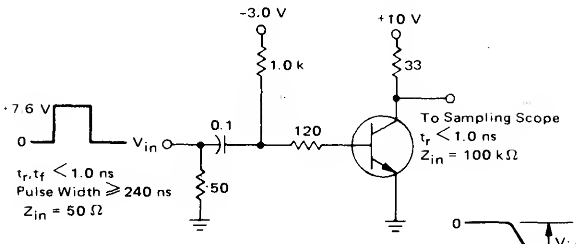
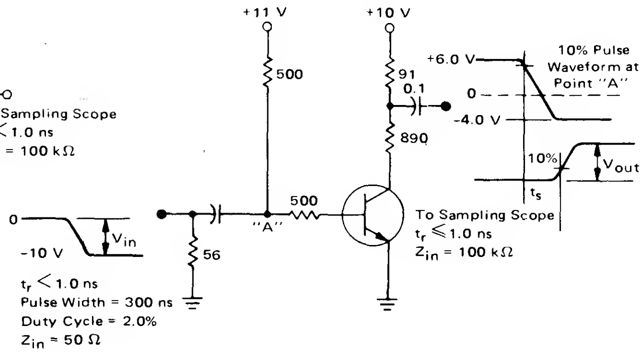


FIGURE 2 – CHARGE STORAGE TIME TEST CIRCUIT



MPS3702
MPS3703

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS3702	MPS3703	Unit
Collector-Emitter Voltage	V_{CEO}	25	30	Vdc
Collector-Base Voltage	V_{CBO}	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 MPS3702 MPS3703	$V_{(BR)CEO}$	 25 30	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPS3702 MPS3703	$V_{(BR)CBO}$	 40 50	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	 MPS3702 MPS3703	h_{FE}	 60 30	 300 150	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage(1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{obo}	—	12	pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

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MPS3704 thru MPS3706

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N4400 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS3704 MPS3705	MPS3706	Unit
Collector-Emitter Voltage	V_{CEO}	30	20	Vdc
Collector-Base Voltage	V_{CBO}	50	40	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_E = 0)	MPS3704 MPS3705 MPS3706	$V_{(BR)CEO}$	30 30 20	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS3704 MPS3705 MPS3706	$V_{(BR)CBO}$	50 50 40	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 50 mAdc, V_{CE} = 2.0 Vdc)	MPS3704 MPS3705 MPS3706	h_{FE}	100 50 30	300 150 600	—
Collector-Emitter Saturation Voltage(1) (I_C = 100 mAdc, I_B = 5.0 mAdc)	MPS3704 MPS3705 MPS3706	$V_{CE(sat)}$	— — —	0.6 0.8 1.0	Vdc
Base-Emitter On Voltage(1) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	0.5	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2.0 Vdc, f = 20 MHz)		f_T	100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	12	pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MPS5172

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0) (V_{CB} = 25 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 — —	 100 10	 nAdc μAdc
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 0)	I_{CES}	—	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	—	500	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.75	—	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	0.5	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	f_T	—	120	—	MHz
Collector-Base Capacitance (V_{CB} = 0, I_E = 0, f = 1.0 MHz)	C_{cb}	1.6	—	10	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	—	750	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

NPN MPS6512 thru MPS6515 PNP MPS6516 thru MPS6519

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

Refer to 2N4125 for graphs.

MAXIMUM RATINGS

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage	V_{CEO}			Vdc
MPS6512, MPS6513		30	—	
MPS6514, MPS6515		25	—	
MPS6516 thru MPS6518		—	40	
MPS6519		—	25	
Collector-Base Voltage	V_{CBO}			Vdc
MPS6512 thru MPS6515		40	—	
MPS6516 thru MPS6518		—	40	
MPS6519		—	25	
Emitter-Base Voltage	V_{EBO}	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$				Vdc
(I_C = 0.5 mAdc, I_B = 0)	MPS6512, MPS6513		30	—	—	
	MPS6514, MPS6515		25	—	—	
(I_C = 0.5 mAdc, I_B = 0)	MPS6516 thru MPS6518		40	—	—	
	MPS6519		25	—	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	—	Vdc
(I_E = 10 μAdc, I_C = 0)			4.0	—	—	
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 Vdc, I_E = 0)			—	—	0.05	
(V_{CB} = 30 Vdc, I_E = 0)	MPS6516 thru MPS6518		—	—	0.05	
(V_{CB} = 20 Vdc, I_E = 0)	MPS6519		—	—	0.05	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6512		50	—	100	
	MPS6513		90	—	180	
	MPS6514		150	—	300	
	MPS6515		250	—	500	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)(1)	MPS6512		30	—	—	
	MPS6513		60	—	—	
	MPS6514		90	—	—	
	MPS6515		150	—	—	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6516		50	—	100	
	MPS6517		90	—	180	
	MPS6518		150	—	300	
	MPS6519		250	—	500	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)(1)	MPS6516		30	—	—	
	MPS6517		60	—	—	
	MPS6518		90	—	—	
	MPS6519		150	—	—	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	—	0.5	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	—	0.5	
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	—	3.5	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			—	—	4.0	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage MPS6520, MPS6521 MPS6522, MPS6523	V_{CEO}	 25 —	 — 25	Vdc
Collector-Base Voltage MPS6520, MPS6521 MPS6522, MPS6523	V_{CBO}	 40 —	 — 25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

NPN MPS6520 MPS6521

PNP MPS6522 MPS6523

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

Refer to BC559 for PNP graphs.

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0) (I_C = 0.5 mAdc, I_B = 0)		$V_{(BR)CEO}$	 25 25	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0) (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	 4.0 4.0	 — —	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	 — —	 0.05 0.05	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc)	 MPS6520 MPS6521	h_{FE}	 100 150	 — —	—
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6520 MPS6521		200 300	400 600	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6522 MPS6523		100 150	— —	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6522 MPS6523		200 300	400 600	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	 — —	 0.5 0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz) (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	 — —	 3.5 3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	 — —	 3.0 3.0	dB

2

MPS6530 thru MPS6532

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N4400 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6530, MPS6531 MPS6532	V_{CEO}	 40 30	Vdc
Collector-Base Voltage MPS6530, MPS6531 MPS6532	V_{CBO}	 60 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625	mW
Junction Temperature	T_J, T_{stg}	150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	 MPS6530, MPS6531 MPS6532	$V_{(BR)CEO}$	 40 30	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	 MPS6530, MPS6531 MPS6532	$V_{(BR)CBO}$	 60 50	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_B = 10\ \mu$Adc, $I_C = 0$) ($I_B = 10\ \mu$Adc, $I_C = 0$)	 All Types All Types	$V_{(BR)EBO}$	 5.0 4.0	 — —	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$, $T_A = 60°C$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 60°C$)	 MPS6530, MPS6531 MPS6532 MPS6530, MPS6531 MPS6532	I_{CBO}	 — — — —	 0.05 0.1 2.0 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	 MPS6530 MPS6531 MPS6530 MPS6531 MPS6532 MPS6530 MPS6531	h_{FE}	 30 60 40 90 30 25 50	 — — 120 270 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	 MPS6530, MPS6532 MPS6531	$V_{CE(sat)}$	 — —	 0.5 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	 MPS6530, MPS6531 MPS6532	$V_{BE(sat)}$	 — —	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz) ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	 All Types All Types	C_{obo}	 — —	 5.0 7.0	pF

MPS6533 thru MPS6535

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6533, MPS6534 MPS6535	V_{CEO}	 40 30	Vdc
Collector-Base Voltage MPS6533, MPS6534 MPS6535	V_{CBO}	 40 30	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625	mW
Junction Temperature	T_J, T_{stg}	150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	 MPS6533, MPS6534 MPS6535	$V_{(BR)CEO}$	 40 30	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 MPS6533, MPS6534 MPS6535	$V_{(BR)CBO}$	 40 30	 — —	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0) (I_B = 10 μAdc, I_C = 0)	 All Types All Types	$V_{(BR)EBO}$	 5.0 4.0	 — —	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C) (V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)	 All Types MPS6533, MPS6534 MPS6535	I_{CBO}	 — — —	 0.05 2.0 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	 MPS6533 MPS6534 MPS6533 MPS6534 MPS6535 MPS6533 MPS6534	h_{FE}	 30 60 40 90 30 25 50	 — — 120 270 — — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	 MPS6533, MPS6535 MPS6534	$V_{CE(sat)}$	 — —	 0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	 MPS6533, MPS6534 MPS6535	$V_{BE(sat)}$	 — —	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	 All Types All Types	C_{obo}	 — —	 5.0 7.0	pF

2

NPN
MPS8098
MPS8099

PNP
MPS8598
MPS8599

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	MPS8098 MPS8598	MPS8099 MPS8599	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
		MPS8098 MPS8099	MPS8598 MPS8599	
Emitter-Base Voltage	V_{EBO}	6.0	5.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

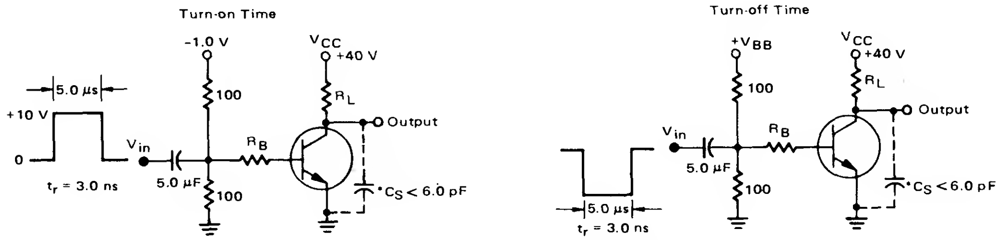
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 MPS8098, MPS8598 MPS8099, MPS8599	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPS8098, MPS8598 MPS8099, MPS8599	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 MPS8098, MPS8099 MPS8598, MPS8599	$V_{(BR)EBO}$	 6.0 5.0	 — —	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MPS8098, MPS8598 MPS8099, MPS8599	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0) (V_{EB} = 4.0 Vdc, I_C = 0)	 MPS8098, MPS8099 MPS8598, MPS8599	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) 0(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	100 100 75	300 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	— —	0.4 0.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	 MPS8098, MPS8598 MPS8099, MPS8599	$V_{BE(on)}$	 0.5 0.6	 0.7 0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	150	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	 MPS8098, MPS8099 MPS8598, MPS8599	C_{obo}	 — —	 6.0 8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	 MPS8098, MPS8099 MPS8598, MPS8599	C_{ibo}	 — —	 25 30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

NPN MPS8098, MPS8099, PNP MPS8598, MPS8599

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

FIGURE 2 – CURRENT-GAIN – BANDWIDTH PRODUCT

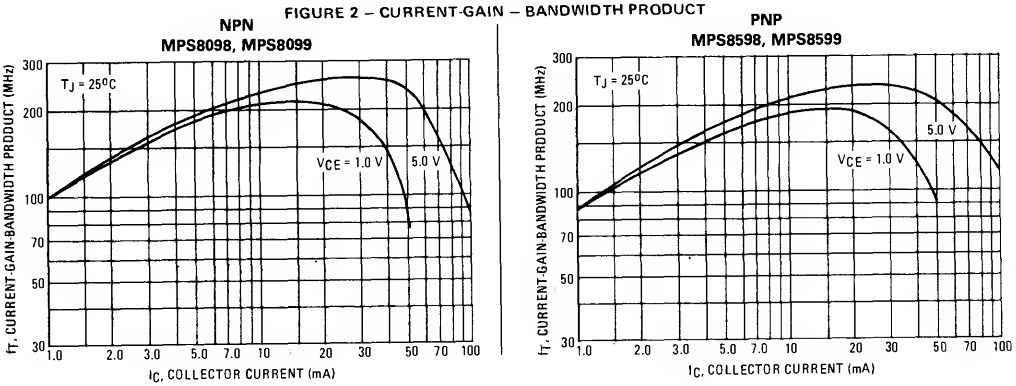


FIGURE 3 – CAPACITANCE

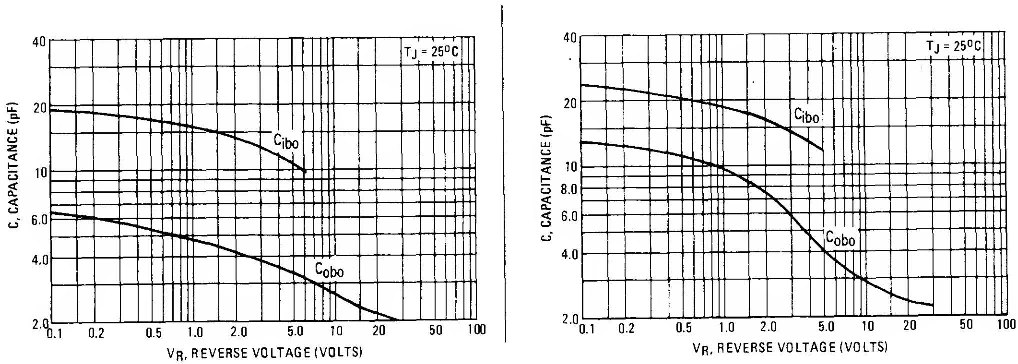
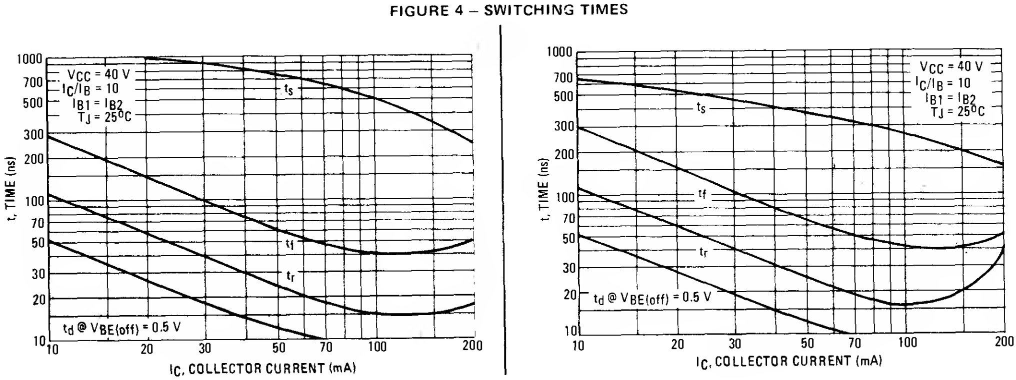


FIGURE 4 – SWITCHING TIMES



NPN MPS8098, MPS8099, PNP MPS8598, MPS8599

FIGURE 5 – THERMAL RESPONSE

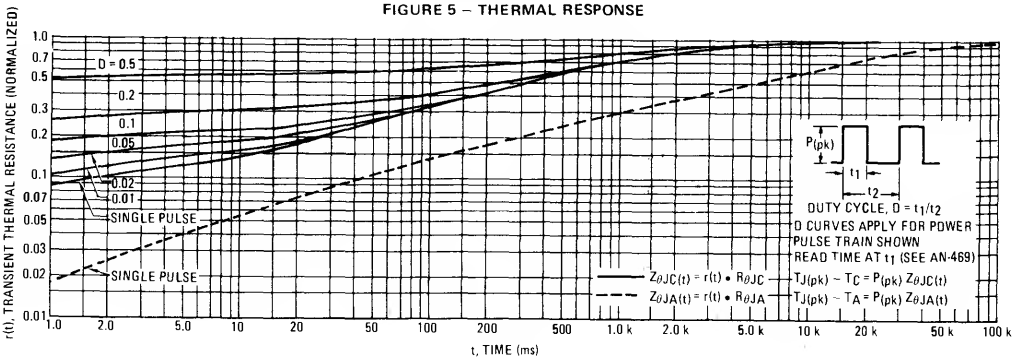


FIGURE 6—ACTIVE REGION, SAFE OPERATING AREA MPS 8098, MPS 8099

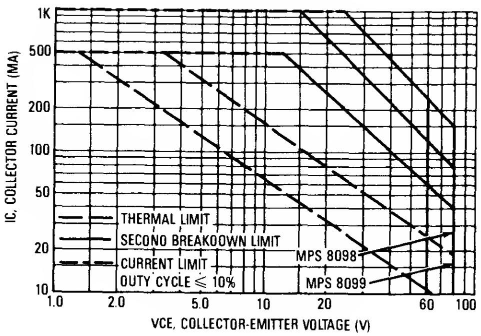
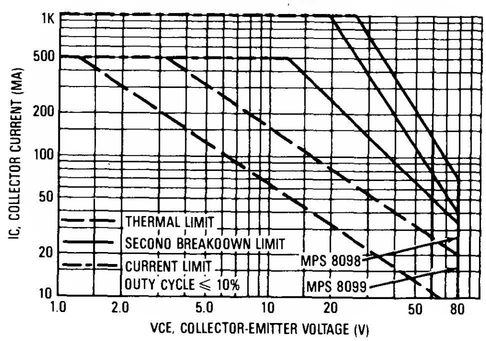


FIGURE 6—ACTIVE REGION, SAFE OPERATING AREA MPS 8598, MPS 8599



MPS8098, MPS8099

FIGURE 7 – DC CURRENT GAIN

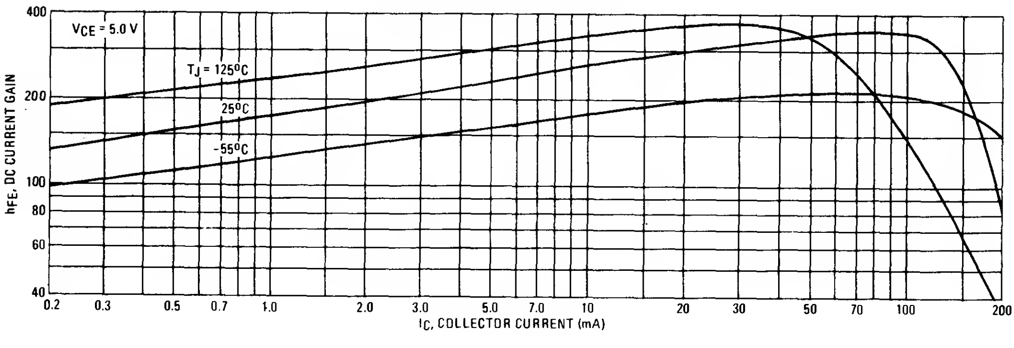


FIGURE 8 – "ON" VOLTAGES

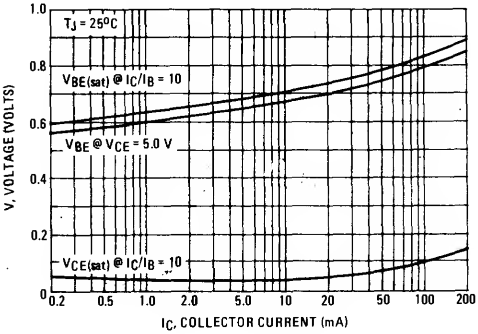


FIGURE 9 – COLLECTOR SATURATION REGION

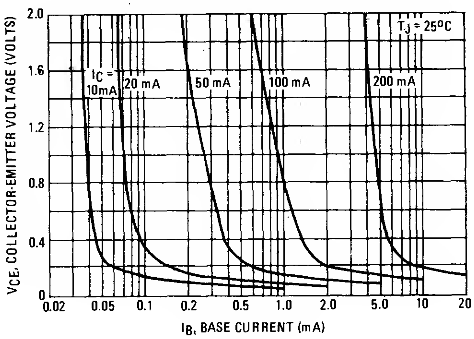
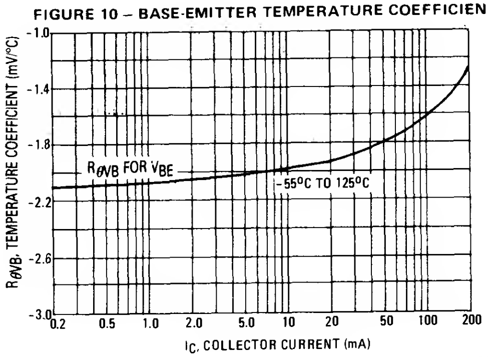


FIGURE 10 – BASE-EMITTER TEMPERATURE COEFFICIENT



MPS8598, MPS8599

FIGURE 11 – DC CURRENT GAIN

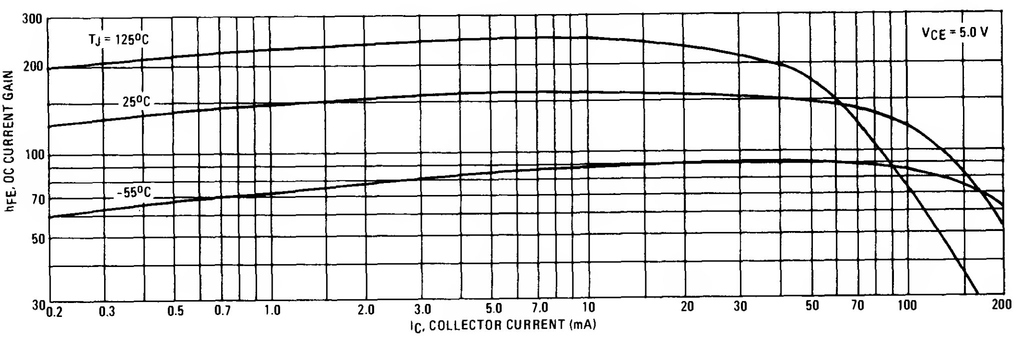


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FIGURE 12 – "ON" VOLTAGES

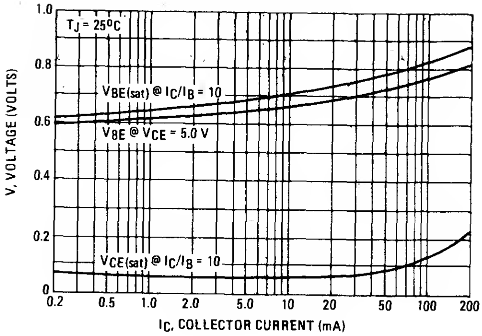


FIGURE 13 – COLLECTOR SATURATION REGION

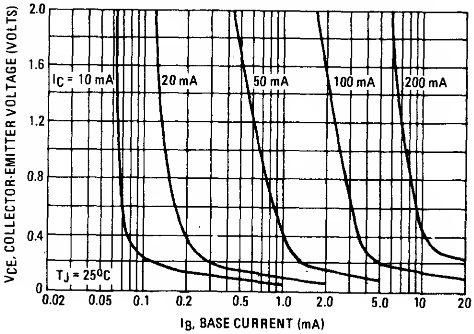
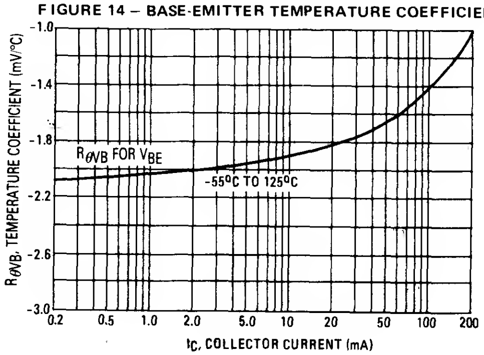


FIGURE 14 – BASE-EMITTER TEMPERATURE COEFFICIENT



2

NPN
MPSA05
MPSA06

PNP
MPSA55
MPSA56

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	MPSA05 MPSA55	MPSA06 MPSA56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

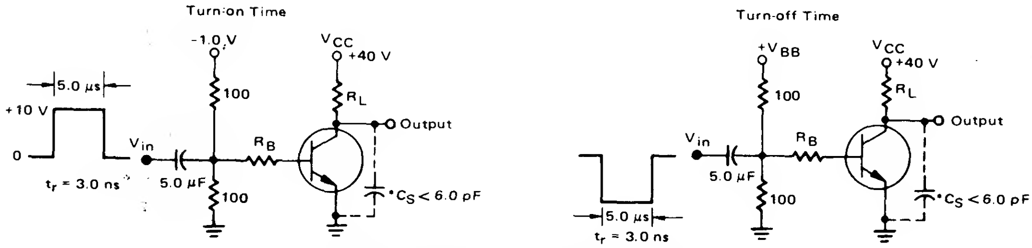
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	MPSA05, MPSA55 MPSA06, MPSA56	$V_{(BR)CEO}$	60 80	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	MPSA05, MPSA55 MPSA06, MPSA56	I_{CBO}	— —	0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	50 50	— —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 10 mA, V_{CE} = 2.0 V, f = 100 MHz)	MPSA05 MPSA06	f_T	100	—	MHz
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc, f = 100 MHz)	MPSA55 MPSA56		50	—	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

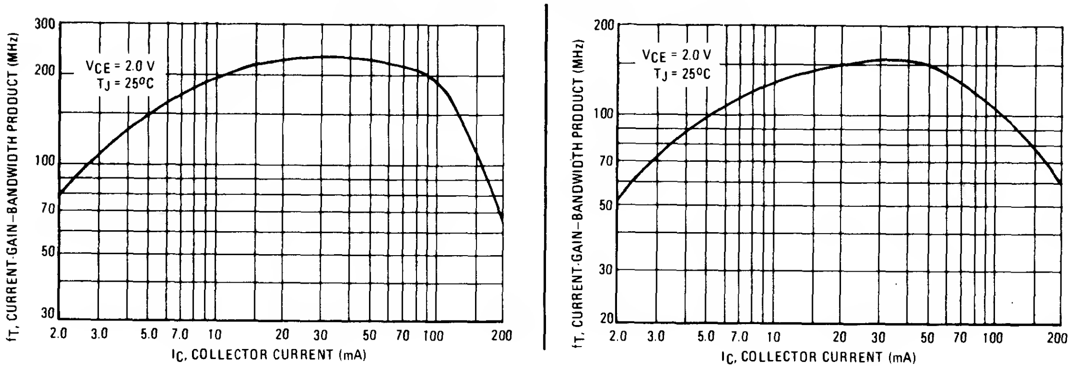


FIGURE 3 – CAPACITANCE

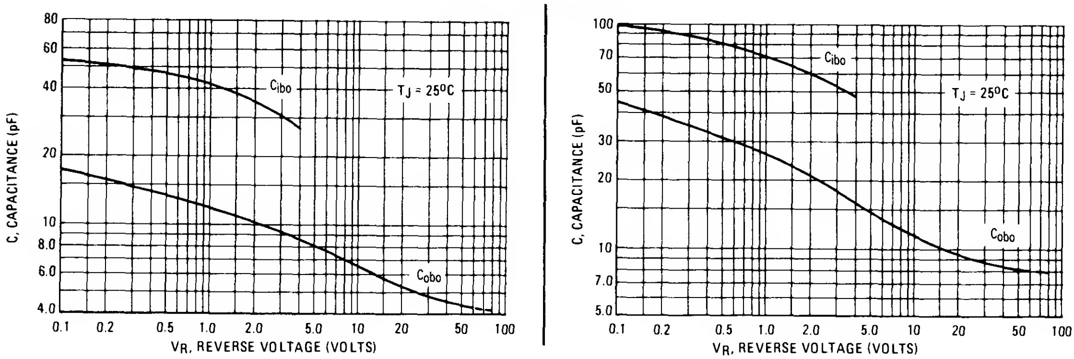
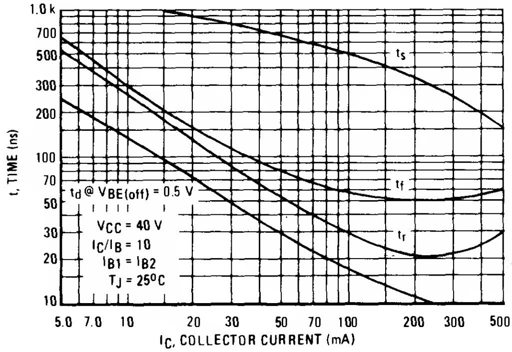


FIGURE 4 – SWITCHING TIME



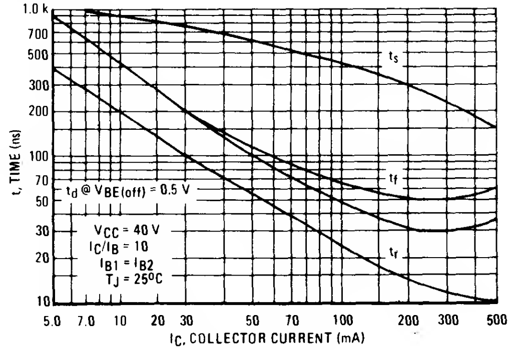


FIGURE 5 – THERMAL RESPONSE

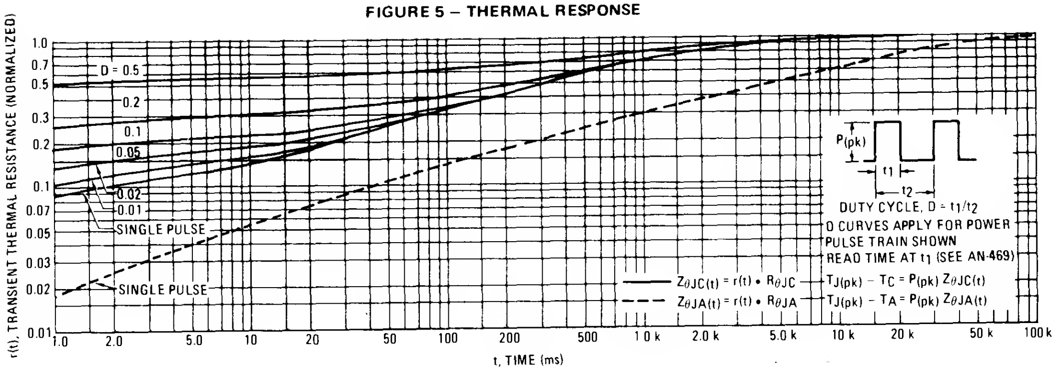
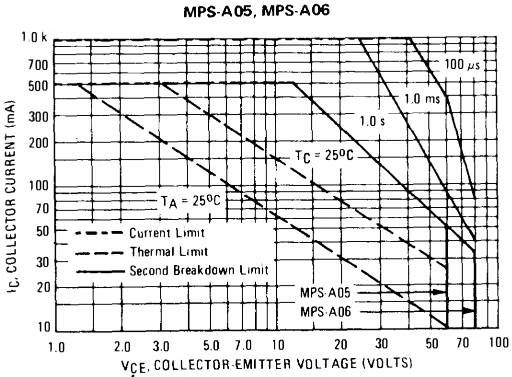
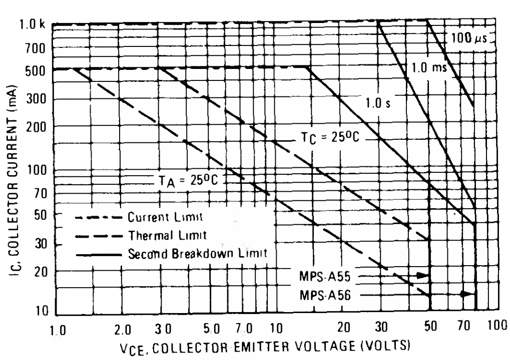


FIGURE 6 – ACTIVE – REGION SAFE OPERATING AREA

MPS-A05, MPS-A06



MPS-A55, MPS-A56



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NPN
MPS-A05, MPS-A06

FIGURE 7 – DC CURRENT GAIN

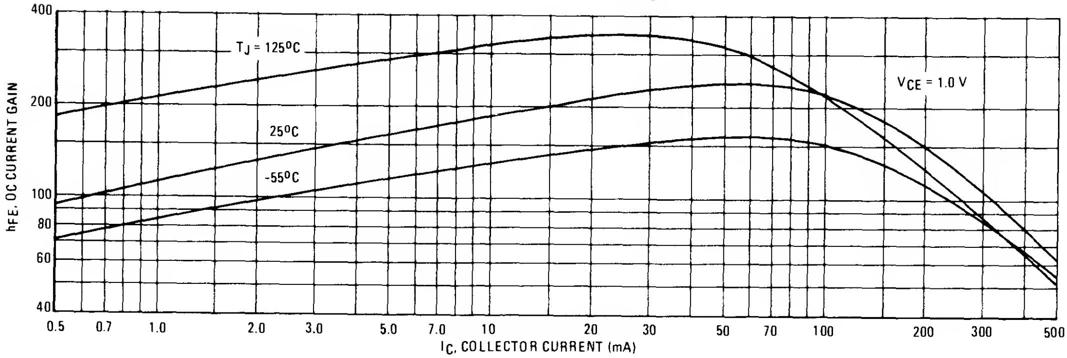


FIGURE 8 – "ON" VOLTAGES

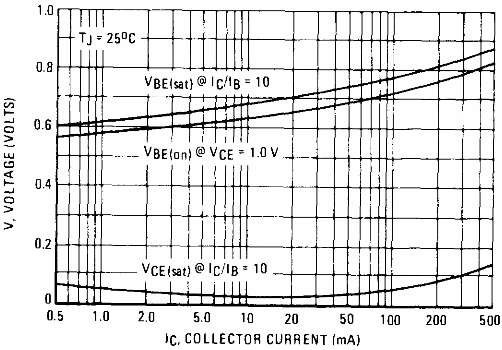


FIGURE 9 – COLLECTOR SATURATION REGION

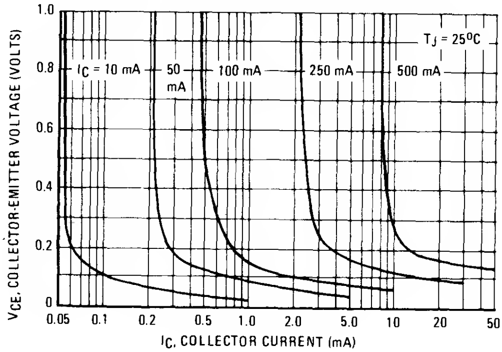
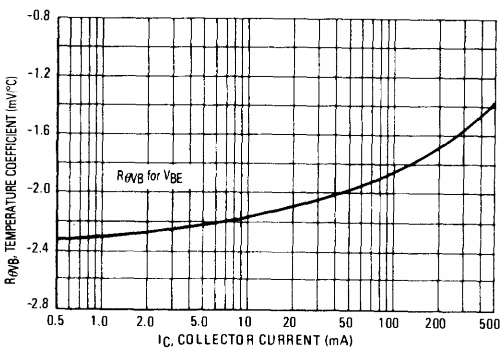


FIGURE 10 – BASE-EMITTER TEMPERATURE COEFFICIENT



PNP
MPS-A55, MPS-A56

FIGURE 11 – DC CURRENT GAIN

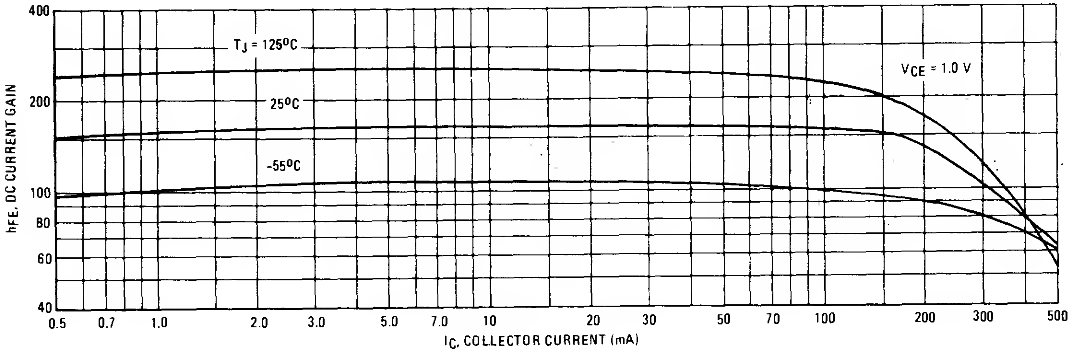


FIGURE 12 – "ON" VOLTAGES

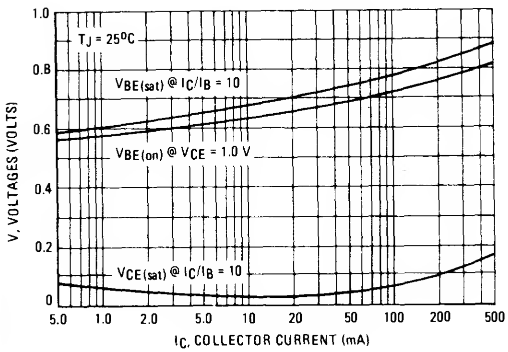


FIGURE 13 – COLLECTOR SATURATION REGION

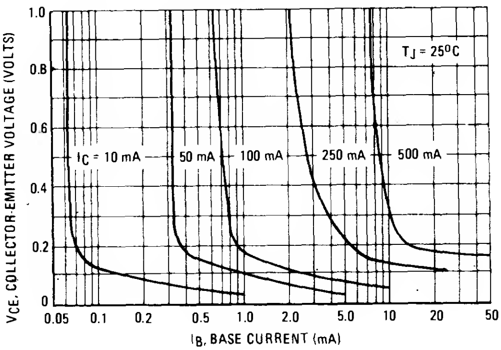
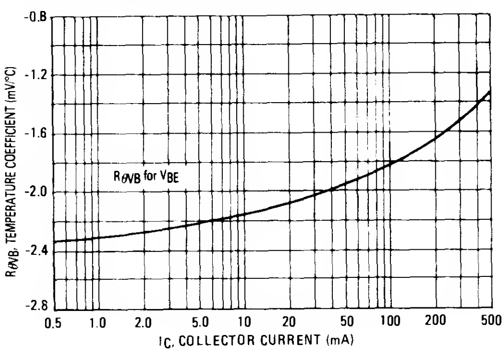


FIGURE 14 – BASE-EMITTER TEMPERATURE COEFFICIENT



MPSA12

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	20	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_B = 0$)	$V_{(BR)CES}$	20	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$)	I_{CES}	—	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20,000	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.01$ mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	V_{BE}	—	—	1.4	Vdc

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

MPSA13
MPSA14

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

2

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_B = 0$)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	MPSA13		5000	—	
	MPSA14		10,000	—	
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	MPSA13		10,000	—	
	MPSA14		20,000	—	
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		V_{BE}	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2

MPSA16
MPSA17

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS-A16	MPS-A17	Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	12	15	Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	MPS-A16 MPS-A17	$V_{(BR)EBO}$	12 15	— —	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	200	600	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS-A16 MPS-A17	f_T	100 80	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	pF

FIGURE 1 – DC CURRENT GAIN

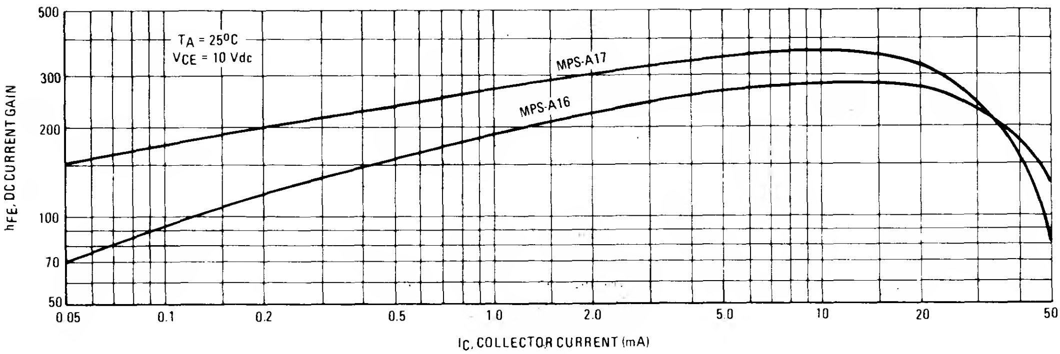


FIGURE 2 – SMALL SIGNAL CURRENT GAIN

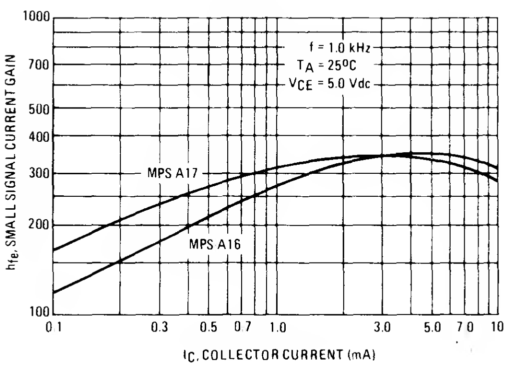


FIGURE 3 – SATURATION AND ON VOLTAGES

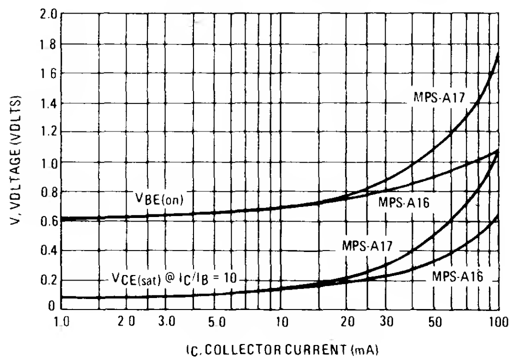


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

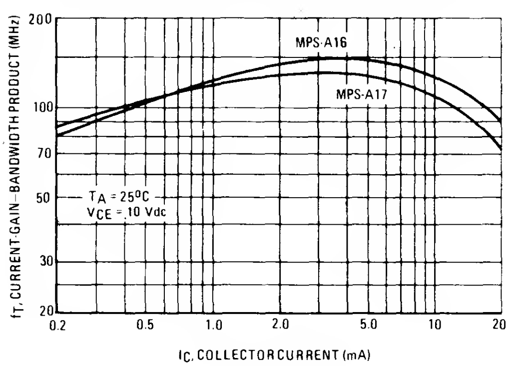
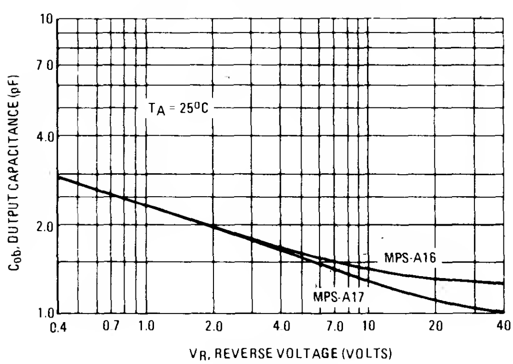


FIGURE 5 – OUTPUT CAPACITANCE



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MPSA18

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

LOW NOISE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	6.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

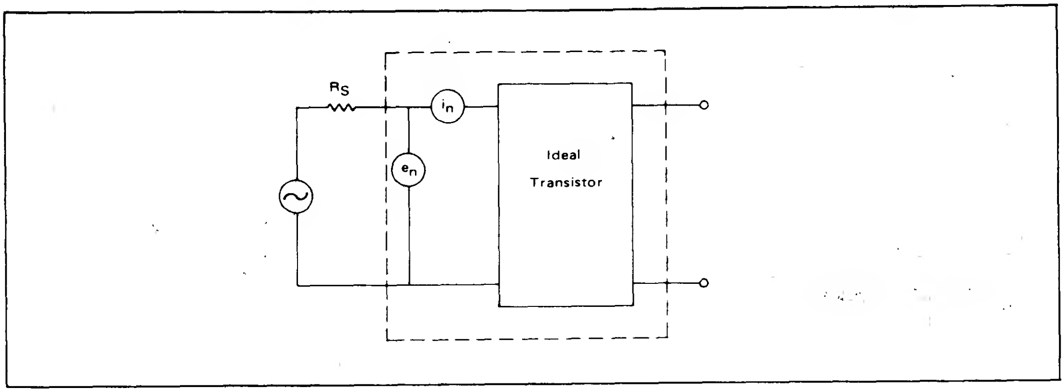
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	1.0	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 400 500 500 500	 580 850 1100 1150	 — — — 1500	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 — 0.08	 0.2 0.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	0.6	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	160	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	1.7	3.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	5.6	6.5	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 kHz) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 100 Hz)	NF	 — —	 0.5 4.0	 1.5 —	dB
Equivalent Short Circuit Noise Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 100 Hz)	V_T	—	6.5	—	$nV/\sqrt{Hz}$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

FIGURE 2 – EFFECTS OF FREQUENCY

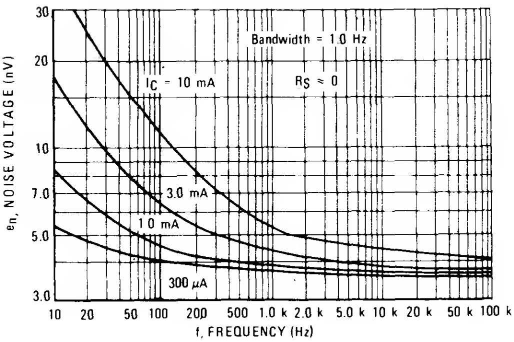


FIGURE 3 – EFFECTS OF COLLECTOR CURRENT

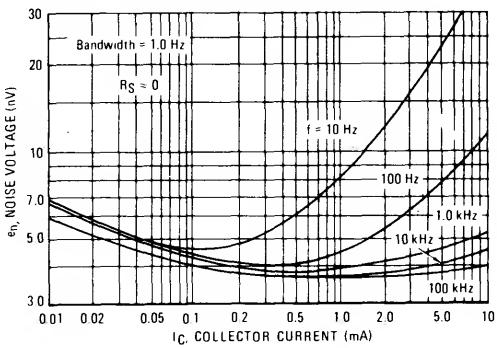


FIGURE 4 – NOISE CURRENT

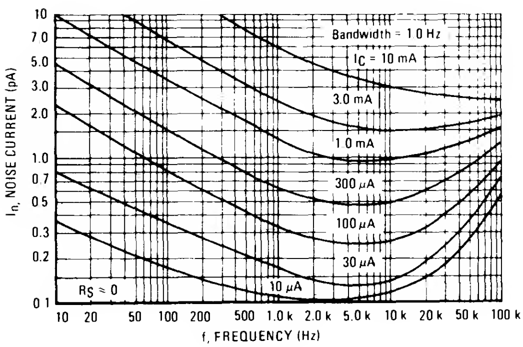
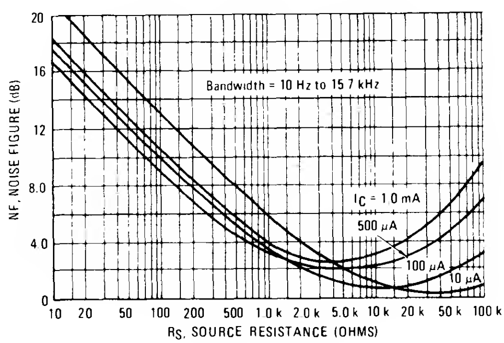


FIGURE 5 – WIDEBAND NOISE FIGURE



100 Hz NOISE DATA

FIGURE 6 – TOTAL NOISE VOLTAGE

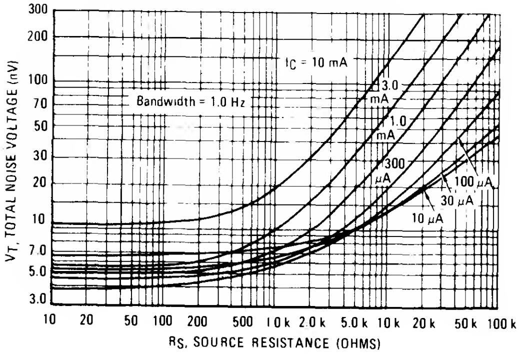


FIGURE 7 – NOISE FIGURE

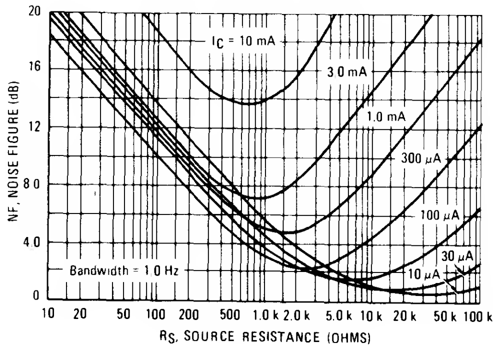


FIGURE 8 — DC CURRENT GAIN

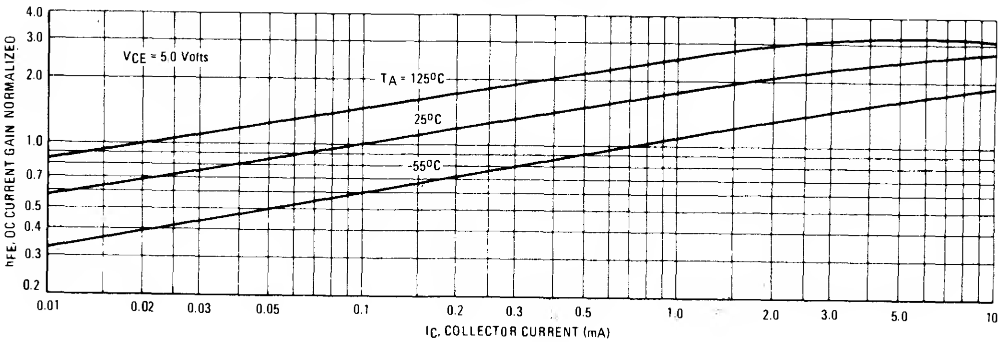


FIGURE 9 – "ON" VOLTAGES

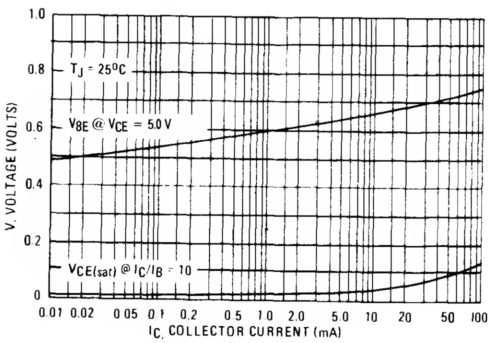


FIGURE 10 – TEMPERATURE COEFFICIENTS

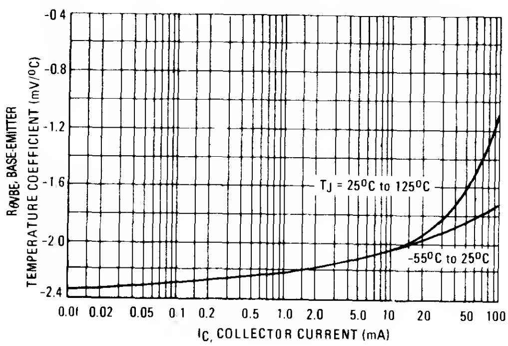


FIGURE 11 – CAPACITANCE

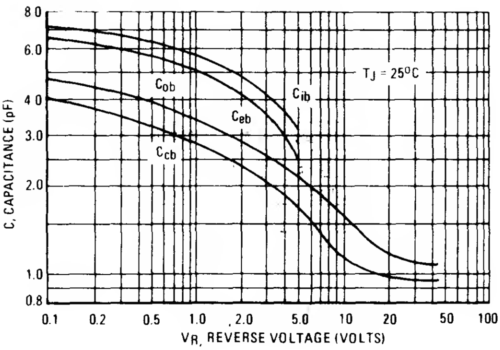
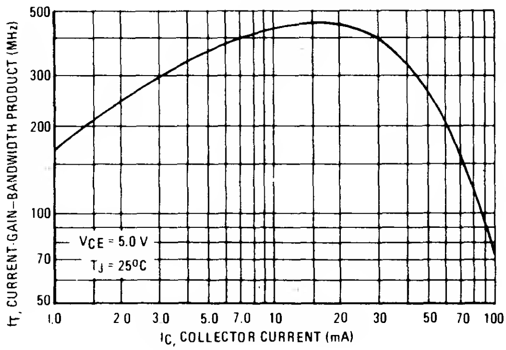


FIGURE 12 – CURRENT-GAIN–BANDWIDTH PRODUCT



2

MPSA25
MPSA26
MPSA27

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS-A25	MPS-A26	MPS-A27	Unit
Collector-Emitter Voltage	V_{CES}	40	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	10			Vdc
Collector Current — Continuous	I_C	500			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	MPSA25 MPSA26 MPSA27	$V_{(BR)CES}$	40 50 60	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPSA25 MPSA26 MPSA27	$V_{(BR)CBO}$	40 50 60	— — —	— — —	Vdc
Collector Cutoff Current (V_{CB} = 30 V, I_E = 0) (V_{CB} = 40 V, I_E = 0) (V_{CB} = 50 V, I_E = 0)	MPSA25 MPSA26 MPSA27	I_{CBO}	— — —	— — —	100 100 100	nAdc
Collector Cutoff Current (V_{CE} = 30 V, V_{BE} = 0) (V_{CE} = 40 V, V_{BE} = 0) (V_{CE} = 50 V, V_{BE} = 0)	MPSA25 MPSA26 MPSA27	I_{CES}	— — —	— — —	500 500 500	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain (I_C = 10 mA, V_{CE} = 5.0 V) (I_C = 100 mA, V_{CE} = 5.0 V)		h_{FE}	10,000 10,000	— —	— —	—
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Small Signal Current Gain (I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)		h_{fe}	1.25	2.4	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DC CURRENT GAIN

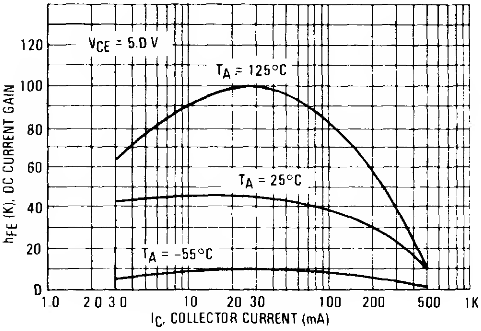


FIGURE 2 — "ON" VOLTAGES

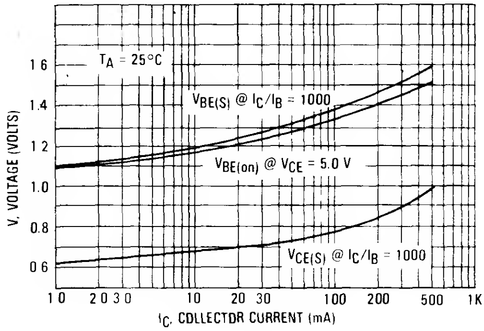


FIGURE 3 — COLLECTOR SATURATION REGION

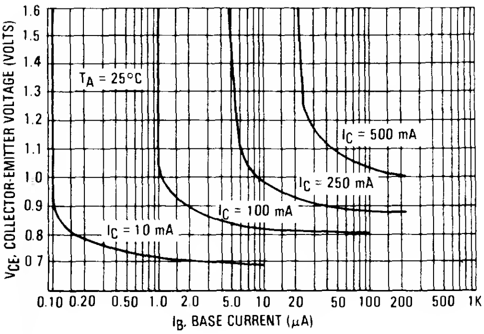


FIGURE 4 — HIGH FREQUENCY CURRENT GAIN

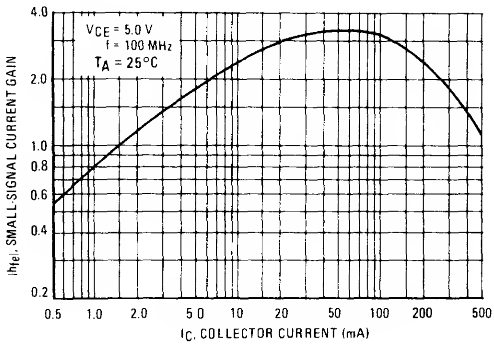
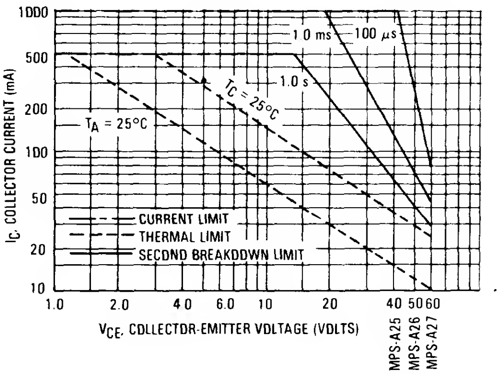


FIGURE 5 — ACTIVE REGION SAFE OPERATING AREA



MPSA28
MPSA29

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA28	MPSA29	Unit
Collector-Emitter Voltage	V_{CES}	80	100	Vdc
Collector-Base Voltage	V_{CBO}	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	 MPSA28 MPSA29	$V_{(BR)CES}$	 80 100	 — —	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	 MPSA28 MPSA29	$V_{(BR)CBO}$	 80 100	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc$, $I_C = 0$)	Both Types	$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MPSA28 MPSA29	I_{CBO}	 — —	 — —	 100 100	nAdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{BE} = 0$) ($V_{CE} = 80$ Vdc, $V_{BE} = 0$)	 MPSA28 MPSA29	I_{CES}	 — —	 — —	 500 500	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)	Both Types	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	 Both Types Both Types	h_{FE}	 10,000 10,000	 — —	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.01$ mAdc) ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)	 Both Types Both Types	$V_{CE(sat)}$	 — —	 0.7 0.8	 1.2 1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	Both Types	$V_{BE(on)}$	—	1.4	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	Both Types	f_T	125	200	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	Both Types	C_{obo}	—	5.0	8.0	pF

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.
(2) $f_T = h_{fe} \cdot f_{test}$.

FIGURE 1 — DC CURRENT GAIN

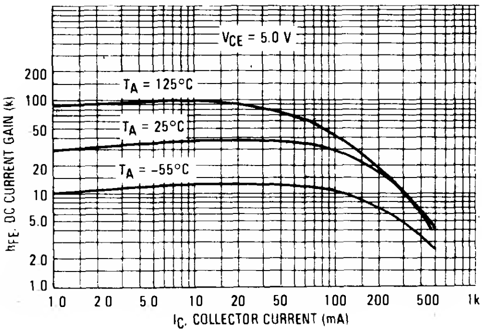


FIGURE 2 — ON VOLTAGES

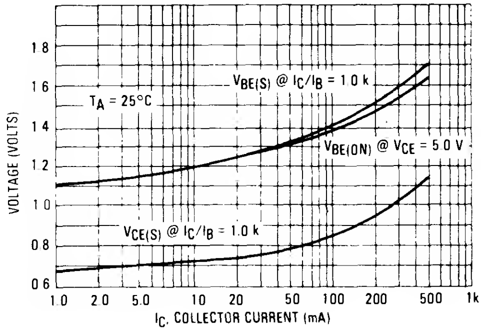


FIGURE 3 — TEMPERATURE COEFFICIENTS

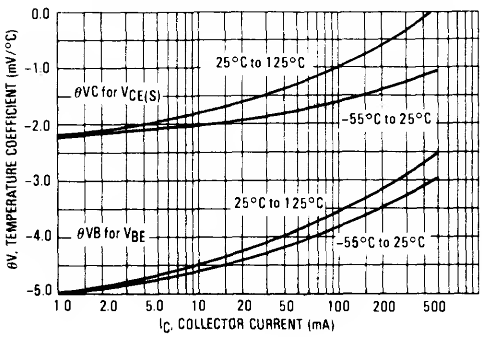


FIGURE 4 — COLLECTOR SATURATION REGION

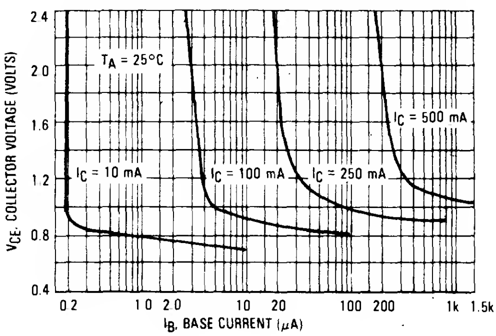


FIGURE 5 — ACTIVE REGION — SAFE OPERATING AREA

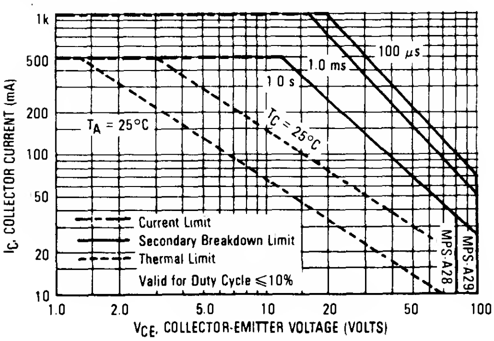
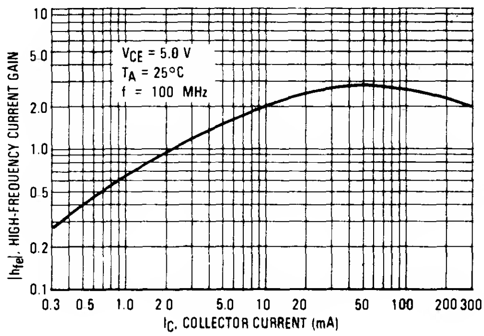


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN



2

MPSA42
MPSA43

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA42	MPSA43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPSA42 MPSA43	$V_{(BR)CEO}$	 300 200	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPSA42 MPSA43	$V_{(BR)CBO}$	 300 200	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	 MPSA42 MPSA43	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 6.0$ Vdc, $I_C = 0$) ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	 MPSA42 MPSA43	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	 Both Types Both Types MPSA42 MPSA43	h_{FE}	 25 40 40 40	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	 MPSA42 MPSA43	$V_{CE(sat)}$	 — —	 0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	 MPSA42 MPSA43	C_{cb}	 — —	 3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

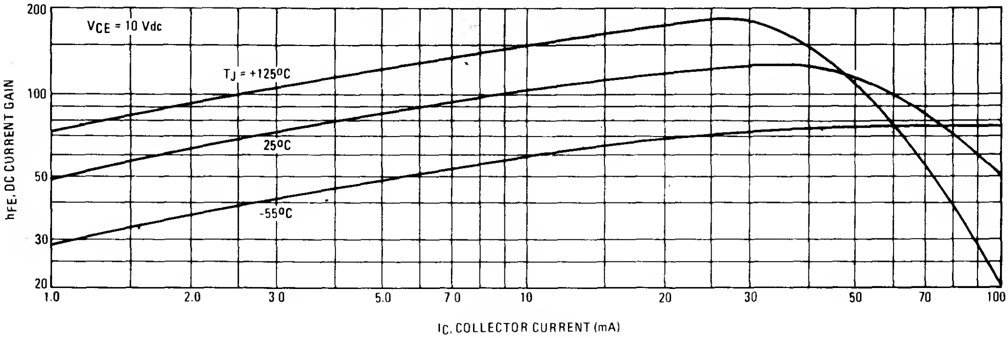


FIGURE 2 – CAPACITANCES

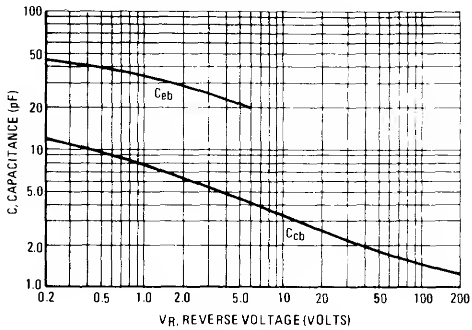


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

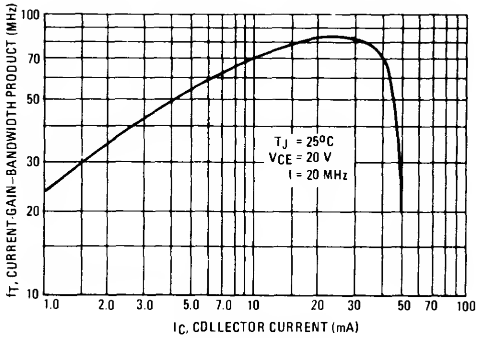


FIGURE 4 – "ON" VOLTAGES

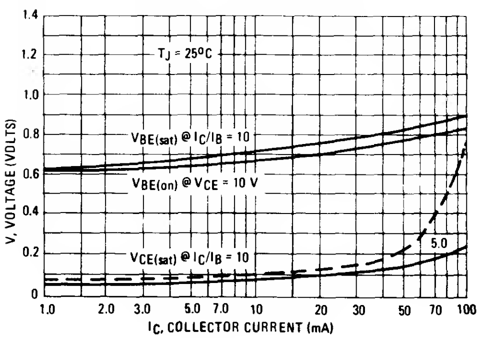
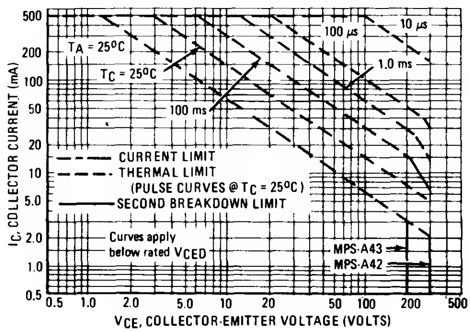


FIGURE 5 – MAXIMUM FORWARD BIAS SAFE OPERATING AREA



2

MPSA44
MPSA45

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA44	MPSA45	Unit
Collector-Emitter Voltage	V_{CEO}	400	350	Vdc
Collector-Base Voltage	V_{CBO}	500	400	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	300		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MPSA44 MPSA45	$V_{(BR)CEO}$	 400 350	 — —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	 MPSA44 MPSA45	$V_{(BR)CES}$	 500 400	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPSA44 MPSA45	$V_{(BR)CBO}$	 500 400	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 400 Vdc, I_E = 0) (V_{CB} = 320 Vdc, I_E = 0)	 MPSA44 MPSA45	I_{CBO}	 — —	 0.1 0.1	μAdc
Collector Cutoff Current (V_{CE} = 400 Vdc, V_{BE} = 0) (V_{CE} = 320 Vdc, V_{BE} = 0)	 MPSA44 MPSA45	I_{CES}	 — —	 500 500	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain(1) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc) (I_C = 100 mAdc, V_{CE} = 10 Vdc)		h_{FE}	40 50 45 40	— 200 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	— — —	0.4 0.5 0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	110	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		h_{fe}	2.0	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSA55, MPSA56

For Specifications, See MPSA05

MPSA44, MPSA45

FIGURE 1 — DC CURRENT GAIN

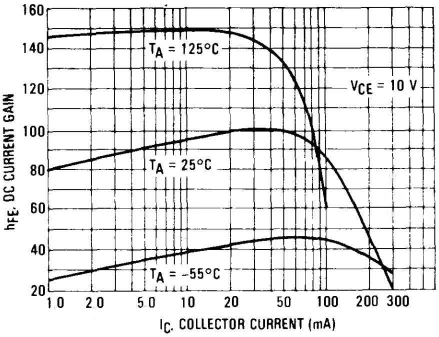


FIGURE 2 — COLLECTOR SATURATION REGION

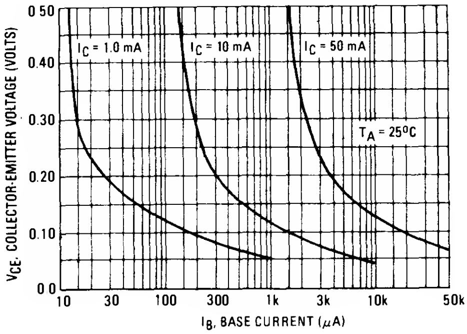


FIGURE 3 — ON VOLTAGES

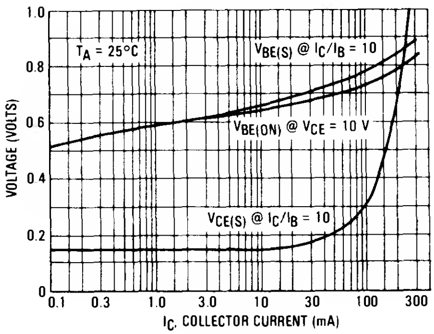


FIGURE 4 — ACTIVE REGION — SAFE OPERATING AREA

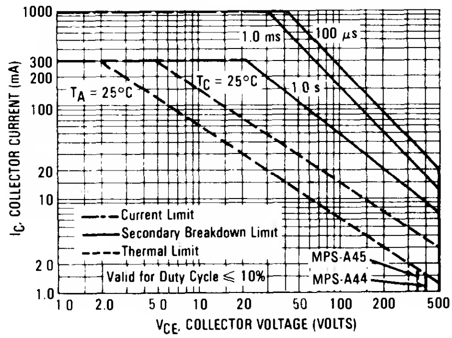


FIGURE 5 — CAPACITANCE

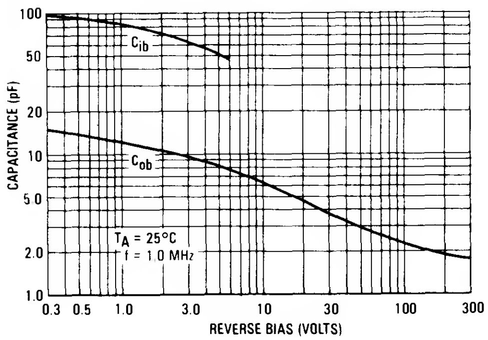
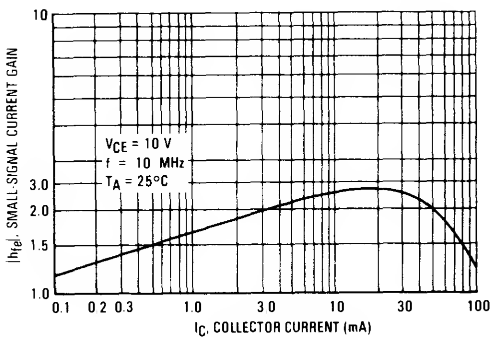
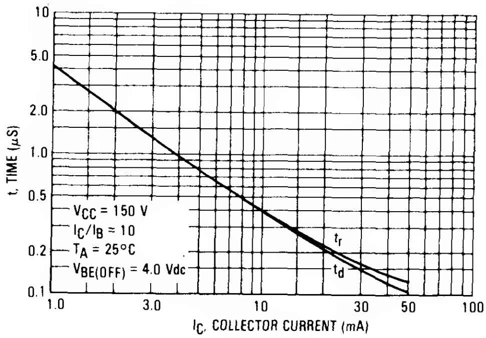


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN



2

FIGURE 7 — TURN-ON SWITCHING TIMES AND TEST CIRCUIT



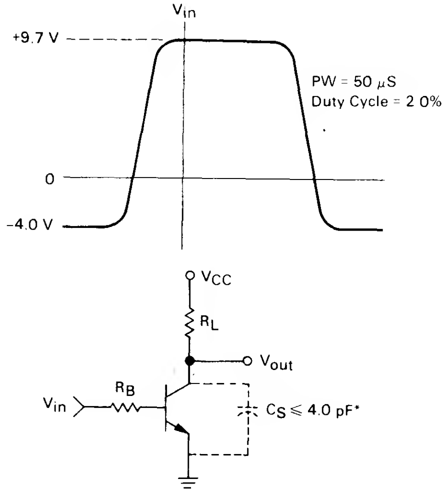
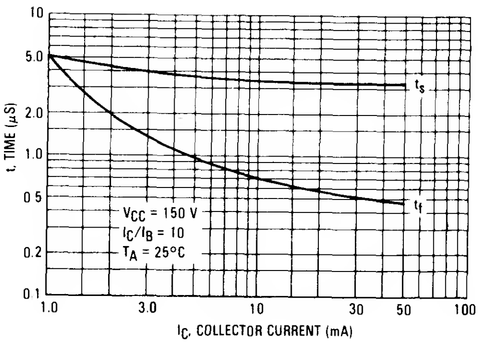
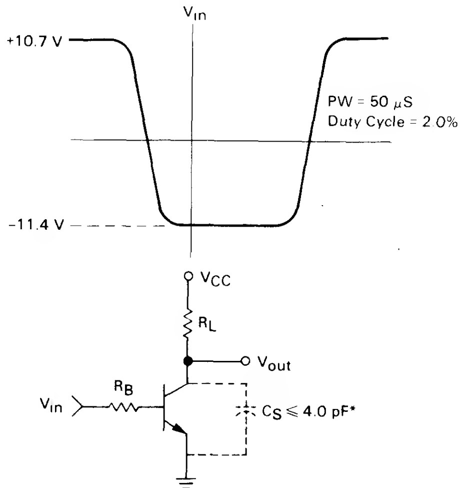


FIGURE 8 — TURN-OFF SWITCHING TIMES AND TEST CIRCUIT





*Total Shunt Capacitance or Test Jig and Connectors.

2

MPSA62
MPSA63
MPSA64

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

PNP SILICON

Refer to MPSA75 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPSA62	MPSA63 MPSA64	Unit
Collector-Emitter Voltage	V_{CES}	20	30	Vdc
Collector-Base Voltage	V_{CBO}	20	30	Vdc
Emitter-Base Voltage	V_{EBO}	10		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	 MPSA62 MPSA63, MPSA64	$V_{(BR)CES}$	 20 30	 — —	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0)	 MPSA62 MPSA63, MPSA64	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	 MPSA63 MPSA64 MPSA62 MPSA63 MPSA64	h_{FE}	 5000 10,000 20,000 10,000 20,000	 — — — — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.01 mAdc) (I_C = 100 mAdc, I_B = 0.1 mAdc)	 MPSA62 MPSA63, MPSA64	$V_{CE(sat)}$	 — —	 1.0 1.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	 MPSA62 MPSA63, MPSA64	$V_{BE(on)}$	 — —	 1.4 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	 MPSA63, MPSA64	f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2

MPSA75
MPSA76
MPSA77

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA75	MPSA76	MPSA77	Unit
Collector-Emitter Voltage	V_{CES}	40	50	60	Vdc
Emitter-Base Voltage	V_{EBO}		10		Vdc
Collector Current — Continuous	I_C		500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D		625 5.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc, V_{BE} = 0$)	MPSA75 MPSA76 MPSA77	$V_{(BR)CES}$	40 50 60	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc, I_E = 0$)	MPSA75 MPSA76 MPSA77	$V_{(BR)CBO}$	40 50 60	— — —	— — —	Vdc
Collector Cutoff Current ($V_{CB} = 30$ V, $I_E = 0$) ($V_{CB} = 40$ V, $I_E = 0$) ($V_{CB} = 50$ V, $I_E = 0$)	MPSA75 MPSA76 MPSA77	I_{CBO}	— — —	— — —	100 100 100	nAdc
Collector Cutoff Current ($V_{CE} = 30$ V, $V_{BE} = 0$) ($V_{CE} = 40$ V, $V_{BE} = 0$) ($V_{CE} = 50$ V, $V_{BE} = 0$)	MPSA75 MPSA76 MPSA77	I_{CES}	— — —	— — —	500 500 500	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 10$ mA, $V_{CE} = 5.0$ V) ($I_C = 100$ mA, $V_{CE} = 5.0$ V)		h_{FE}	10,000 10,000	— —	— —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mA, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mA, $V_{CE} = 5.0$ Vdc)		V_{BE}	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current Gain — High Frequency ($I_C = 10$ mA, $V_{CE} = 5.0$ V, f = 100 MHz)		$\lvert h_{fe} \rvert$	1.25	2.4	—	—

FIGURE 1 — DC CURRENT GAIN

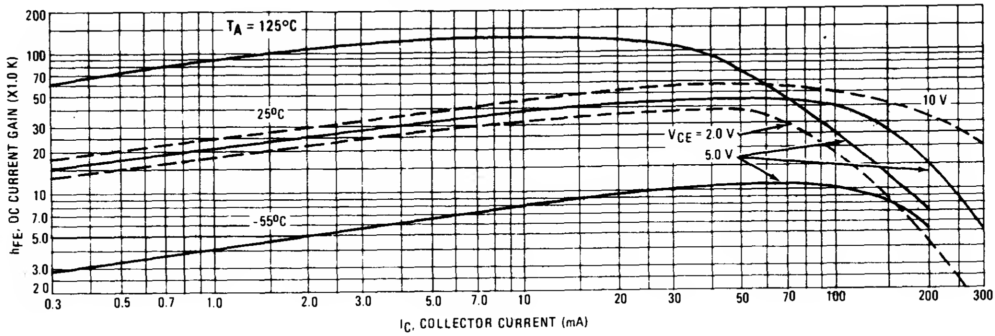


FIGURE 2 — "ON" VOLTAGE

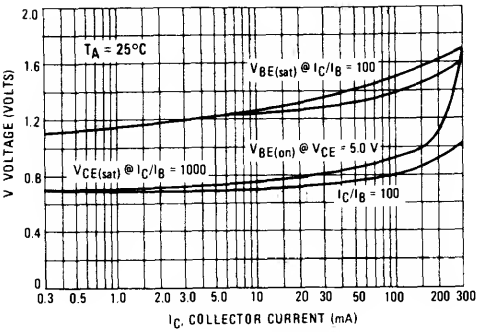


FIGURE 3 — COLLECTOR SATURATION REGION

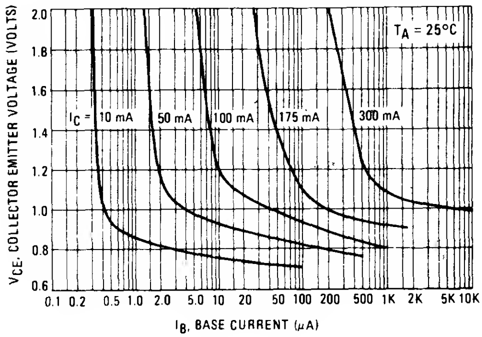


FIGURE 4 — HIGH FREQUENCY CURRENT GAIN

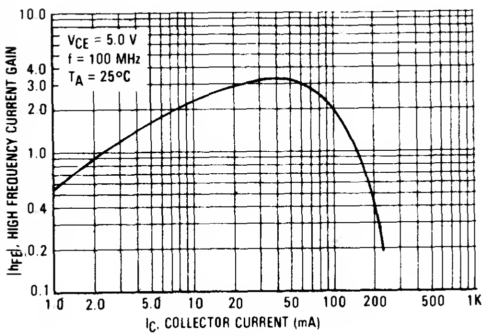
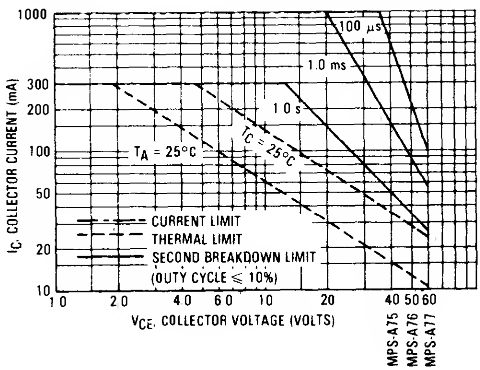


FIGURE 5 — ACTIVE REGION, SAFE OPERATING AREA



2

MPSA92
MPSA93

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS-A92	MPS-A93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	MPSA92 MPSA93	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPSA92 MPSA93	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	MPSA92 MPSA93	I_{CBO}	— —	0.25 0.25	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	Both Types Both Types MPSA92 MPSA93	h_{FE}	25 40 25 25	— — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	MPSA92 MPSA93	$V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MPSA92 MPSA93	C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

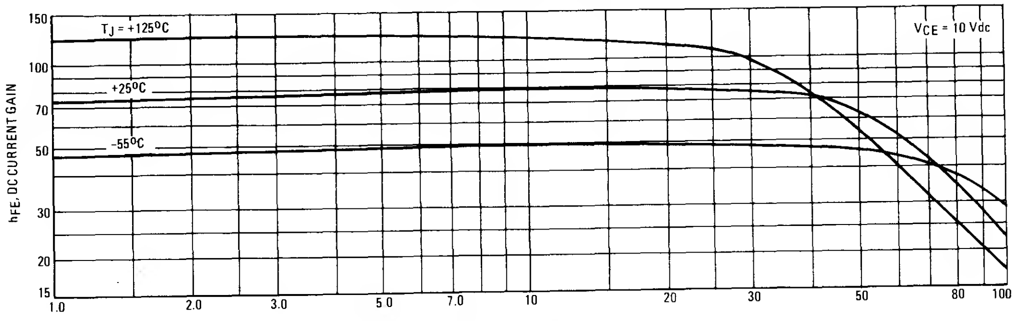


FIGURE 2 – CAPACITANCES

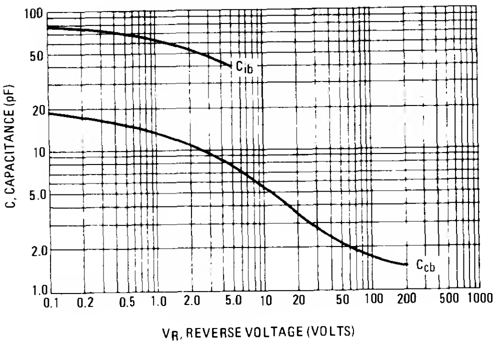


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

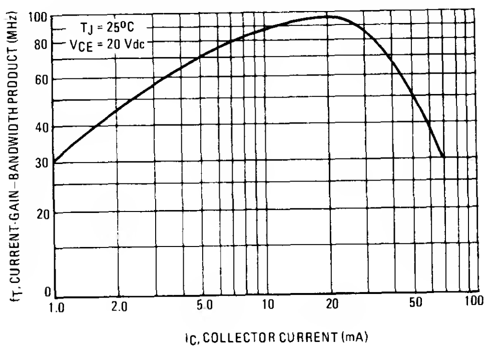


FIGURE 4 – "ON" VOLTAGES

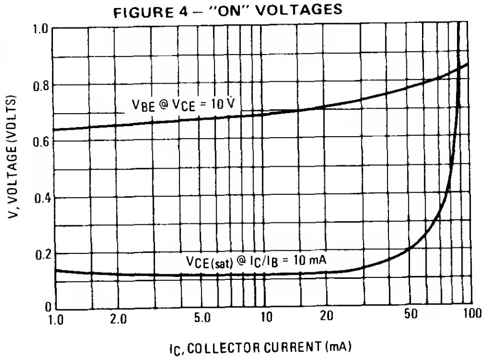
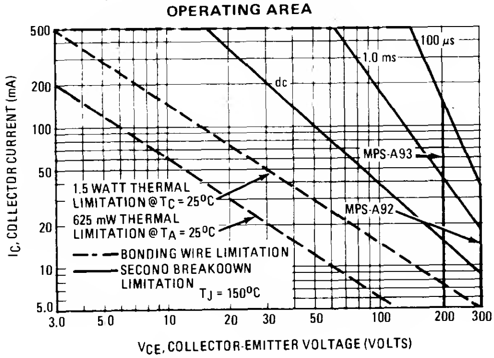


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



2

MPSH04
MPSH05

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	80	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc) MPSH04 MPSH05	h_{FE}	30 30	— —	120 150	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Crrent-Gain — Bandwidth Product ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	80	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)	C_{cb}	—	—	1.6	pF
Output Admittance ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{oe}	—	—	5.0	μmhos
Noise Figure ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 50$ ohms, f = 1.0 MHz) MPSH04	NF	—	—	2.0	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSH10
MPSH11

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

VHF/UHF TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	60	—	—
Collector-Emitter Saturation Voltage ($I_C = 4.0$ mAdc, $I_B = 0.4$ mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	V_{BE}	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	650	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.7	pF
Common-Base Feedback Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz) MPS-H10 MPS-H11	C_{rb}	0.35 0.6	0.65 0.9	pF
Collector Base Time Constant ($I_C = 4.0$ mAdc, $V_{CB} = 10$ Vdc, f = 31.8 MHz)	$r_b'C_c$	—	9.0	ps

2

COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{ib}, INPUT ADMITTANCE

FIGURE 1 – RECTANGULAR FORM

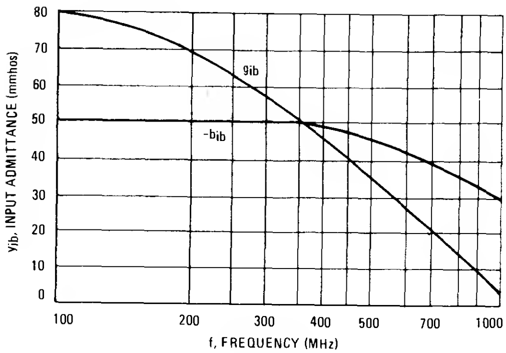
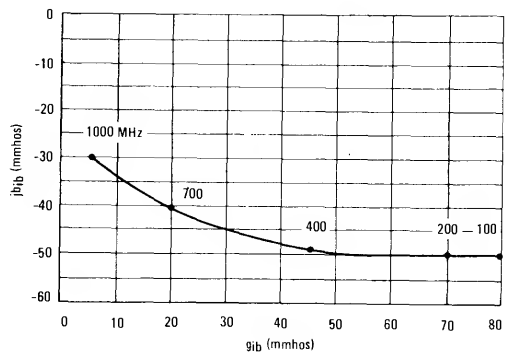


FIGURE 2 – POLAR FORM



COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{fb}, FORWARD TRANSFER ADMITTANCE

FIGURE 3 – RECTANGULAR FORM

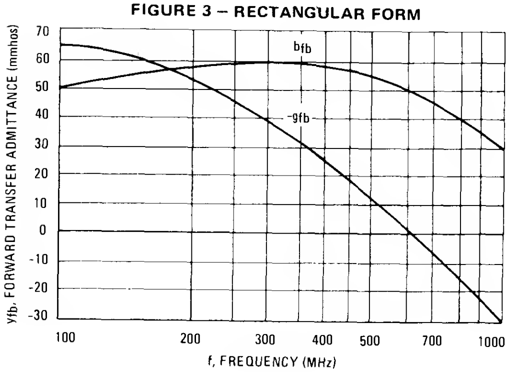
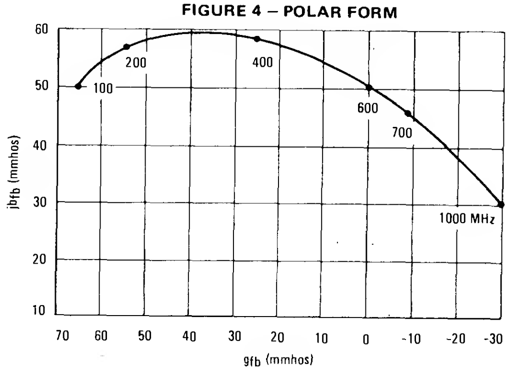


FIGURE 4 – POLAR FORM



y_{rb}, REVERSE TRANSFER ADMITTANCE

FIGURE 5 – RECTANGULAR FORM

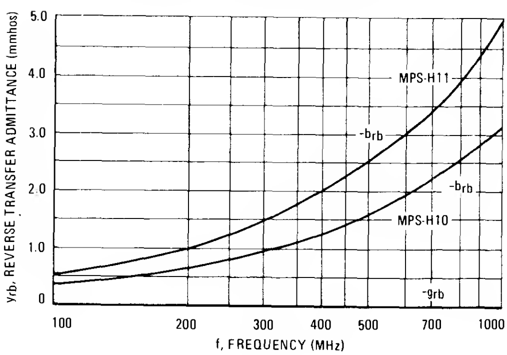
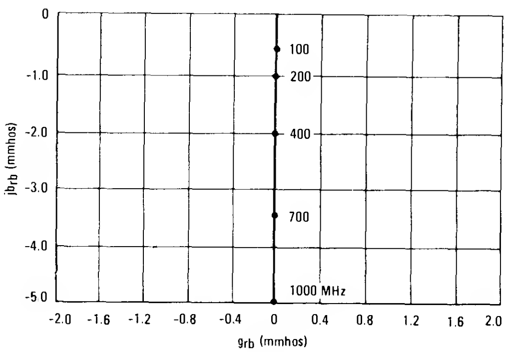


FIGURE 6 – POLAR FORM



y_{ob}, OUTPUT ADMITTANCE

FIGURE 7 – RECTANGULAR FORM

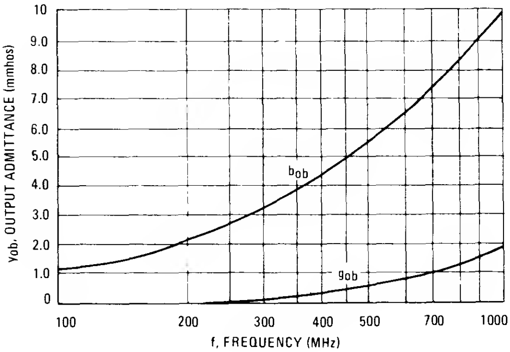
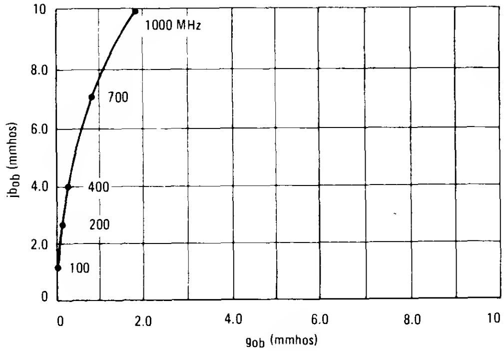


FIGURE 8 – POLAR FORM



MPSH17

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

CATV TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	—	250	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	800	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)	C_{cb}	0.3	—	0.9	pF
Small-Signal Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	30	—	—	—
Noise Figure ($I_C = 5.0$ mAdc, $V_{CC} = 12$ Vdc, $R_S = 50$ ohms, f = 200 MHz)	NF	—	—	6.0	dB
FUNCTIONAL TEST					
Amplifier Power Gain ($I_C = 5.0$ mAdc, $V_{CC} = 12$ Vdc, $R_S = 50$ ohms, f = 200 MHz)	G_{pe}	—	24	—	dB

MPSH34

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

IF TRANSISTOR

NPN SILICON

Refer to MPSH24 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 7.0$ mAdc, $V_{CE} = 15$ Vdc) ($I_C = 20$ mAdc, $V_{CE} = 2.0$ Vdc)	h_{FE}	 40 15	 — —	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 7.0$ mAdc, $V_{CE} = 15$ Vdc)	$V_{BE(on)}$	—	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 15$ mAdc, $V_{CE} = 15$ Vdc, f = 100 MHz)	f_T	500	720	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.25	0.32	pF
Current-Gain — Bandwidth Ratio ($I_C = 15$ mAdc to $I_C = 20$ mAdc, $V_{CE} = 15$ Vdc)	$\frac{f_{T15}}{f_{T20}}$	—	—	1.6	—

2

MPSH54
MPSH55

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	80	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc) MPSH54 MPSH55	h_{FE}	30 30	— —	120 150	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	80	—	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	—	—	1.6	pF
Output Admittance (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	—	—	15	μmhos
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 MHz) MPSH54	NF	—	—	2.0	dB

MPSH81

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

RF AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	—	—	—
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	—	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	0.85	pF
Collector-Emitter Capacitance (I_B = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{ce}	—	—	0.65	pF

TYPICAL COMMON-BASE y-PARAMETERS
(V_{CB} = 10 Vdc, T_A = 25°C, Frequency Points in MHz)

FIGURE 1 – INPUT ADMITTANCE

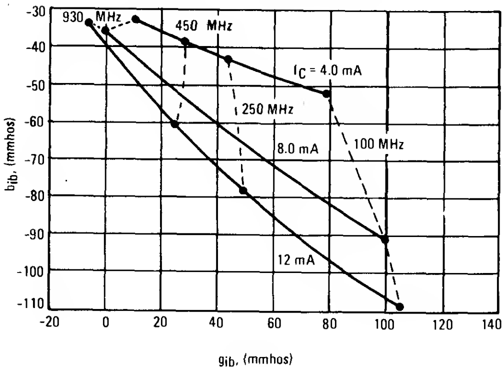


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

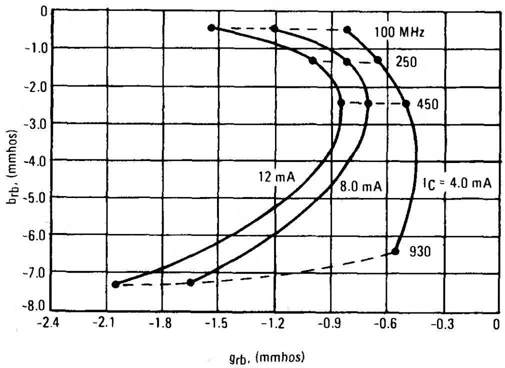


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

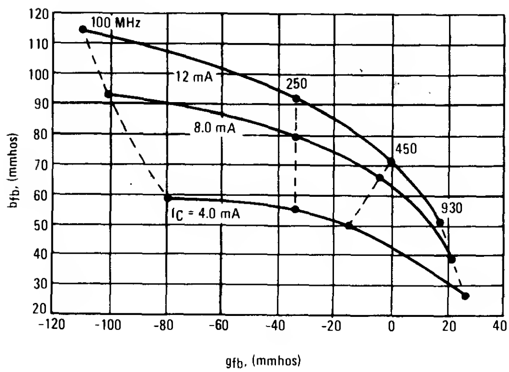


FIGURE 4 – OUTPUT ADMITTANCE

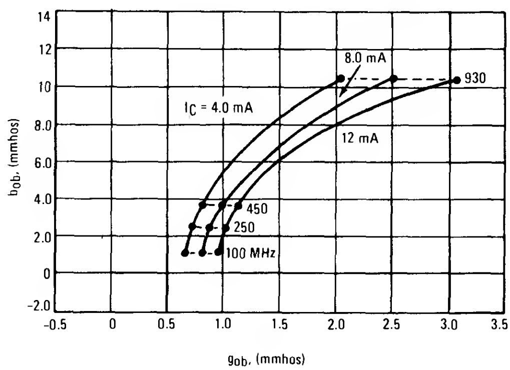
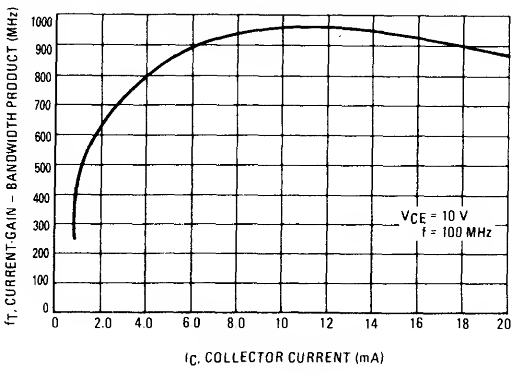


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT



MPSL01

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	120	Vdc
Collector-Base Voltage	V_{CBO}	140	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

Refer to 2N5550 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	120	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	140	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	—	1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	300	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.20 0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)(1)	$V_{BE(sat)}$	 — —	 1.2 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	60	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	—	—

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

2

MPSL51

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N5400 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	100	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	100	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)	I_{CBO}	—	1.0	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain(1) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	40	250	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	 — —	 0.25 0.30	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	 — —	 1.2 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	20	—	—

(1) Pulse Test: Pulse Test = 300 μs, Duty Cycle = 2.0%.

2

MPSW01
MPSW01A

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH CURRENT TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPSW01 / MPSW01A	V_{CEO}	30 / 40	Vdc
Collector-Base Voltage MPSW01 / MPSW01A	V_{CBO}	40 / 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1000	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MPSW01 MPSW01A	$V_{(BR)CEO}$	30 40	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPSW01 MPSW01A	$V_{(BR)CBO}$	40 50	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0)	MPSW01 MPSW01A	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	55 60 50	— — —	—
Collector-Emitter Saturation Voltage (I_C = 1000 mAdc, I_B = 100 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DC CURRENT GAIN

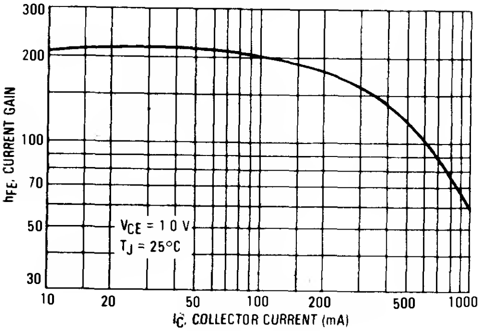


FIGURE 2 — COLLECTOR SATURATION REGION

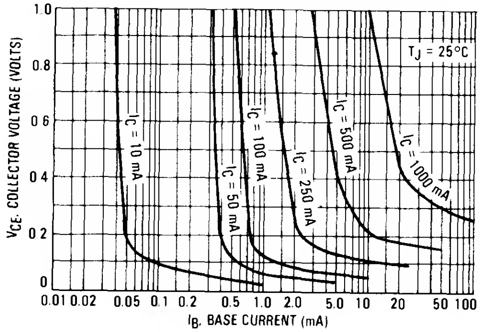


FIGURE 3 — ON VOLTAGES

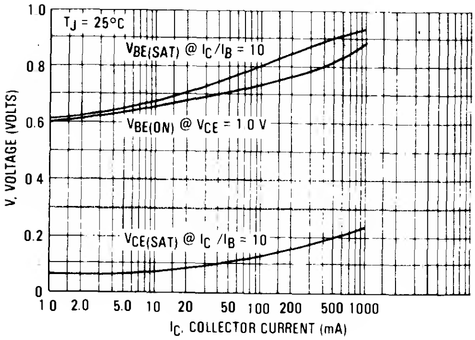


FIGURE 4 — TEMPERATURE COEFFICIENT

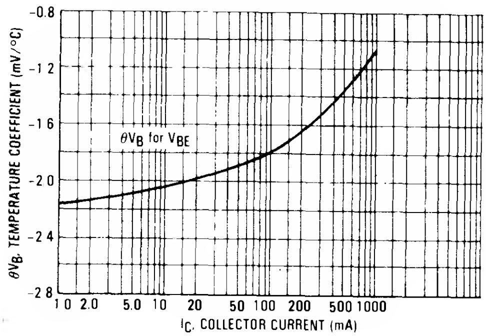


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

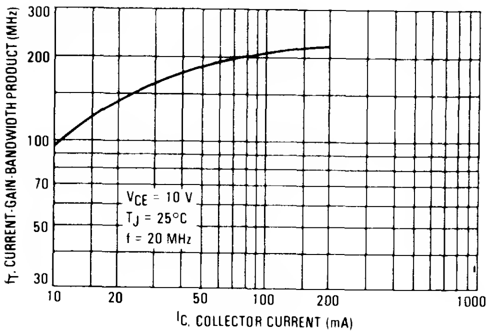


FIGURE 6 — CAPACITANCE

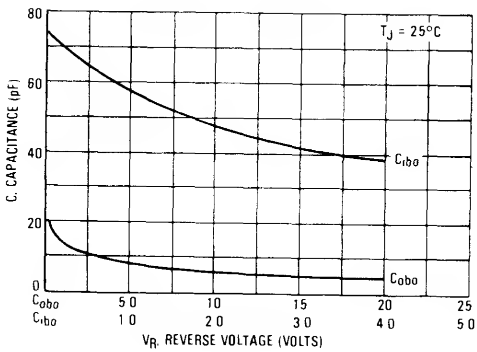
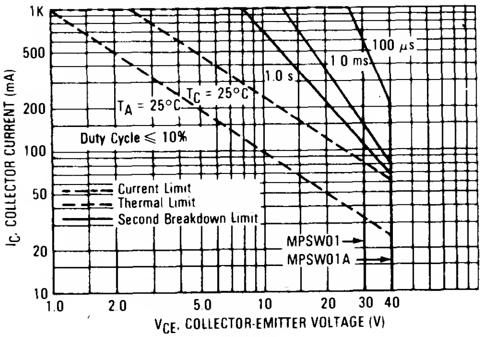


FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



2

MPSW05
MPSW06

CASE 29-03, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW05	MPSW06	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPSW05 MPSW06	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 40$ Vdc, $I_B = 0$) ($V_{CE} = 60$ Vdc, $I_B = 0$)	 MPSW05 MPSW06	I_{CEO}	 — —	 0.5 0.5	μAdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$)	 MPSW05 MPSW06	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 80 60	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 250$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	0.40	Vdc
Base-Emitter Saturation Voltage ($I_C = 250$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)		C_{obo}	—	12	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPSW10

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTOR

Refer to MPSW42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.2	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 40 40	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	—	0.75	Vdc
Base-Emitter On Voltage (I_C = 30 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	45	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	3.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPSW13
MPSW14

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPSW13 MPSW14		5000 10,000	— —	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MPSW13 MPSW14		10,000 20,000	— —	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 1 — ACTIVE REGION SAFE OPERATING AREA

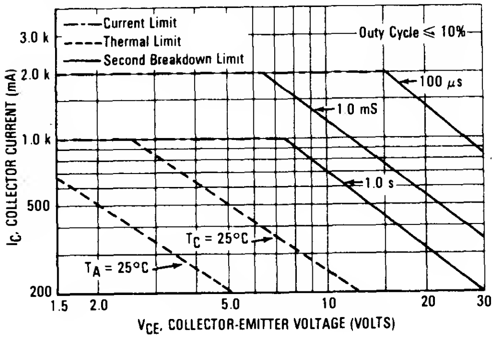


FIGURE 2 — DC CURRENT GAIN

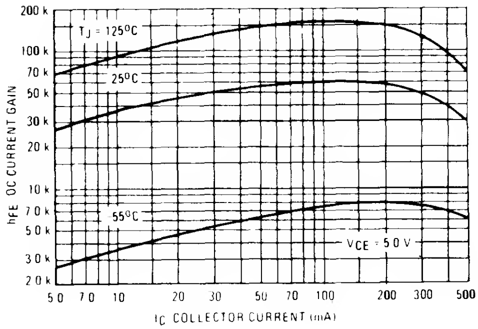


FIGURE 3 — COLLECTOR-SATURATION REGION

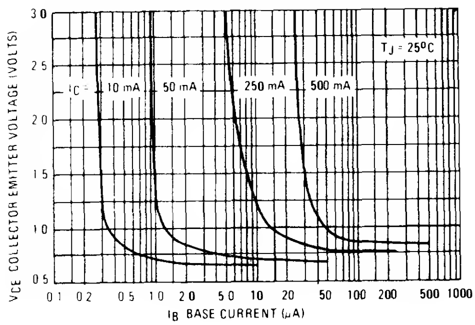


FIGURE 4 — ON VOLTAGES

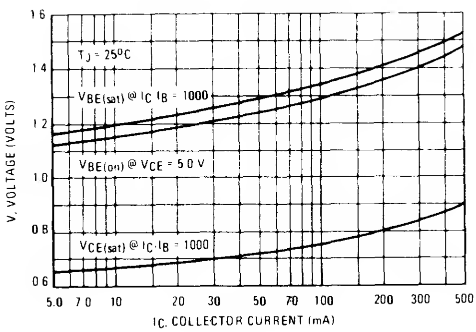


FIGURE 5 — TEMPERATURE COEFFICIENTS

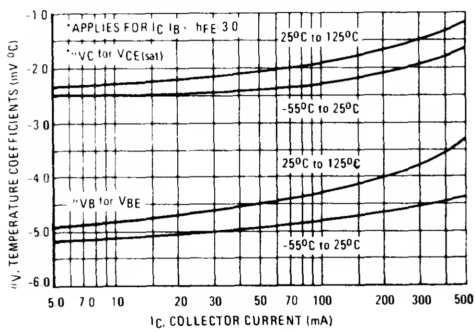


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN

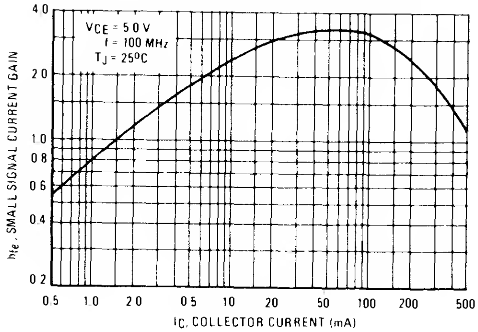
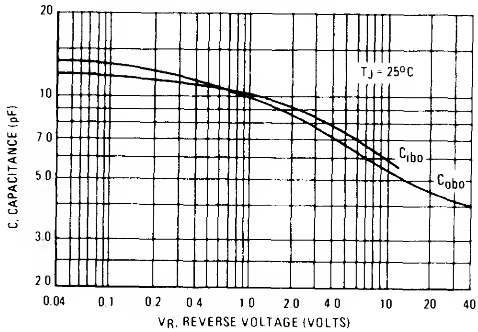


FIGURE 7 — CAPACITANCE



MPSW42
MPSW43

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPSW42	MPSW43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPSW42 MPSW43	$V_{(BR)CEO}$	 300 200	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPSW42 MPSW43	$V_{(BR)CBO}$	 300 200	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	 MPSW42 MPSW43	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0$ Vdc, $I_C = 0$) ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	 MPSW42 MPSW43	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	 Both Types Both Types MPSW42 MPSW43	h_{FE}	 25 40 40 40	 — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	 MPSW42 MPSW43	$V_{CE(sat)}$	 — —	 0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	 MPSW42 MPSW43	C_{cb}	 — —	 3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 — D.C. CURRENT GAIN

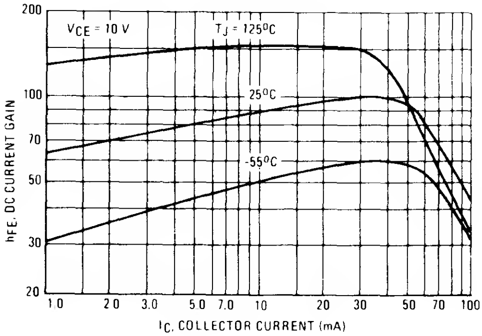


FIGURE 2 — COLLECTOR SATURATION REGION

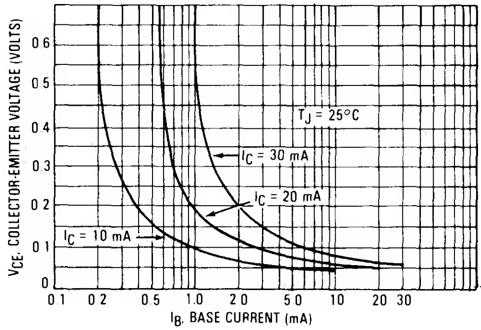


FIGURE 3 — ON VOLTAGES

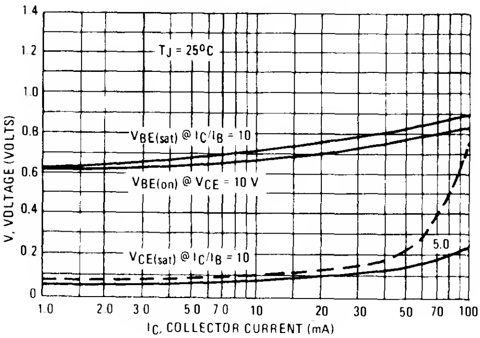


FIGURE 4 — TEMPERATURE COEFFICIENTS

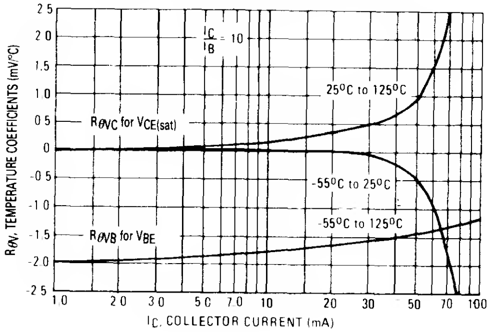


FIGURE 5 — CAPACITANCE

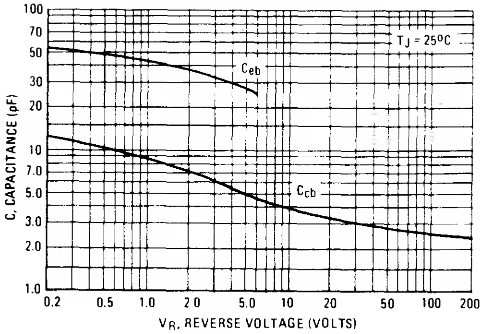


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

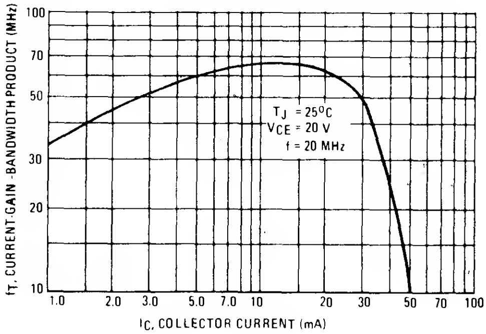
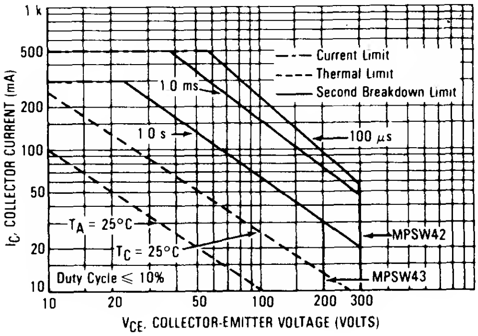


FIGURE 7 — ACTIVE REGION SAFE OPERATING AREA



2

MPSW45

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	 25,000 15,000 4,000	 150,000 — —	—
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	—	2.0	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	6.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSW51
MPSW51A

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH CURRENT TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPSW51 MPSW51A	V_{CEO}	 30 40	Vdc
Collector-Base Voltage MPSW51 MPSW51A	V_{CBO}	 40 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1000	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPSW51 MPSW51A	$V_{(BR)CEO}$	 30 40	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	 MPSW51 MPSW51A	$V_{(BR)CBO}$	 40 50	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$)	 MPSW51 MPSW51A	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 55 60 50	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DC CURRENT GAIN

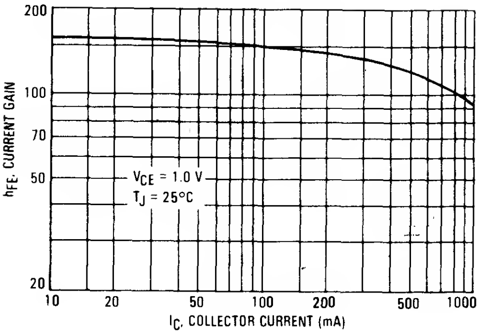


FIGURE 2 — COLLECTOR SATURATION REGION

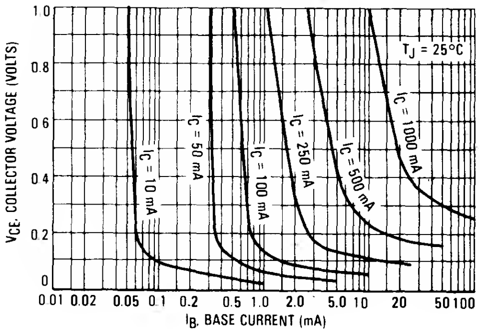


FIGURE 3 — ON VOLTAGES

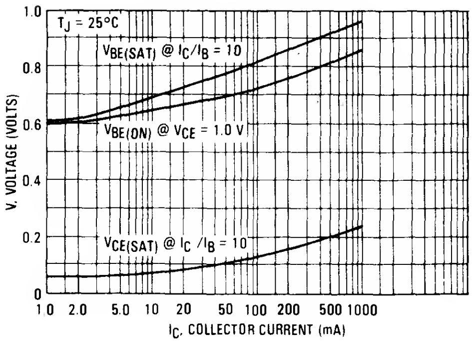


FIGURE 4 — TEMPERATURE COEFFICIENT

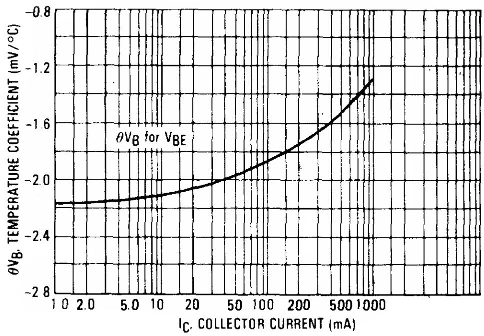


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

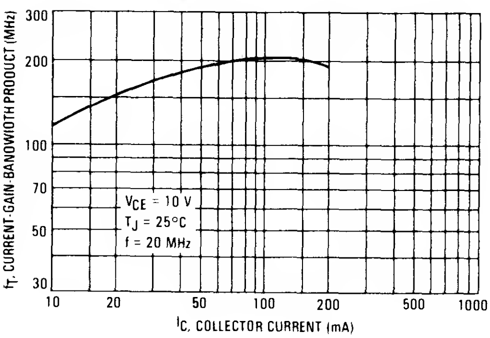


FIGURE 6 — CAPACITANCE

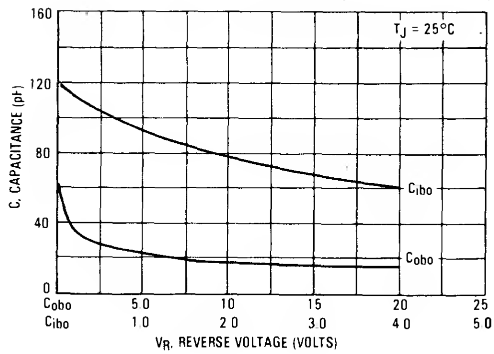
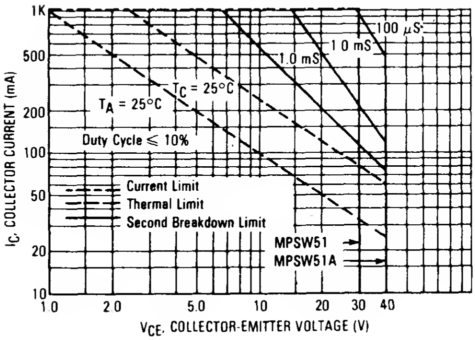


FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



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MPSW55
MPSW56

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW55	MPSW56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MPSW55 MPSW56	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, I_B = 0) (V_{CE} = 60 Vdc, I_B = 0)	 MPSW55 MPSW56	I_{CEO}	 — —	 0.5 0.5	μAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	 MPSW55 MPSW56	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 80 50	 — —	—
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 250 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{obo}	—	15	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — D.C. CURRENT GAIN

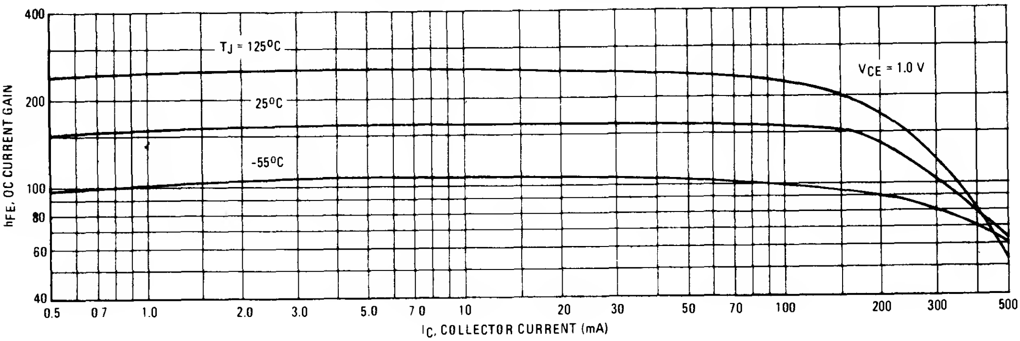

FIGURE 2 — COLLECTOR SATURATION REGION

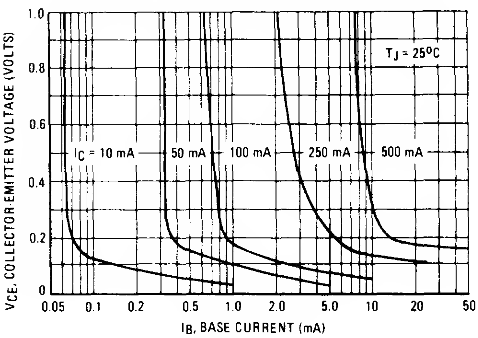

FIGURE 3 — ON VOLTAGES

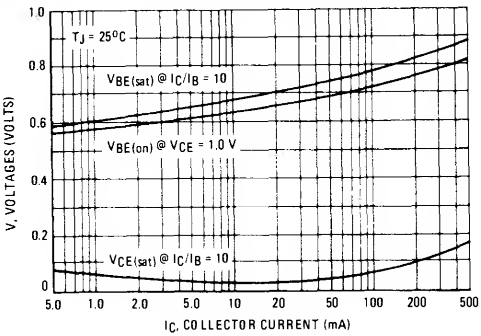

FIGURE 4 — BASE-EMITTER TEMPERATURE COEFFICIENT

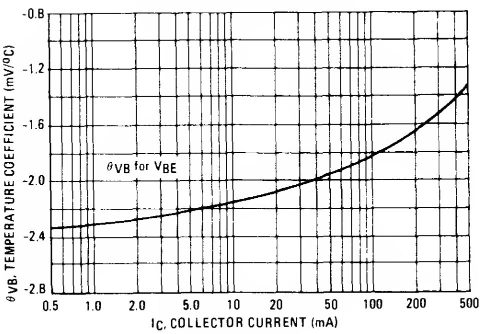

FIGURE 5 — CAPACITANCE

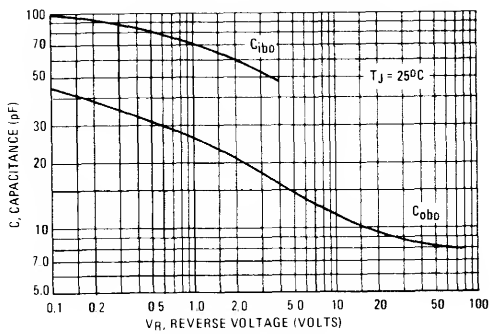

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FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

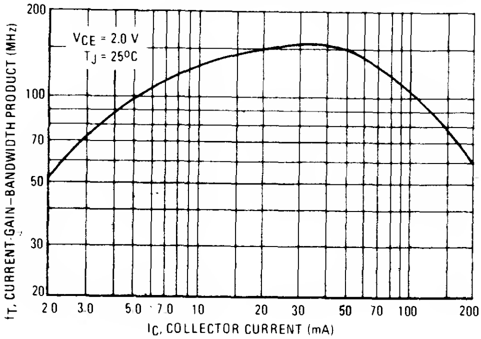
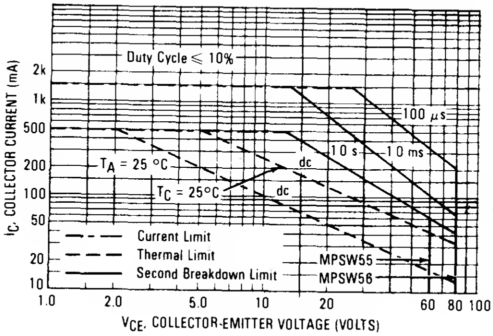


FIGURE 7 — ACTIVE REGION - SAFE OPERATING AREA



MPSW60

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to MPSW92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10.0$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$)	I_{CBO}	—	0.2	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	 25 30 25	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{CE(sat)}$	—	0.75	Vdc
Base-Emitter On Voltage ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc)	$V_{BE(on)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)	f_T	60	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 10 MHz)	C_{cb}	—	8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPSW63
MPSW64

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

DARLINGTON TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW63 MPSW64	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPSW63 MPSW64	h_{FE}	5,000 10,000	— —	—
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MPSW63 MPSW64		10,000 20,000	— —	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

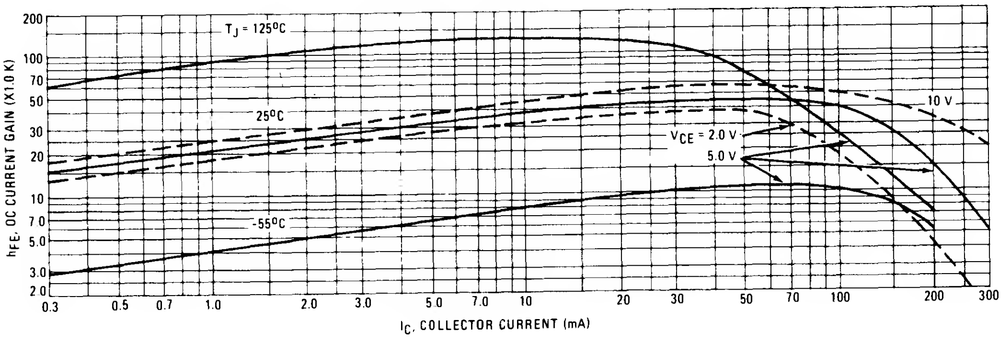


FIGURE 2 – "ON" VOLTAGE

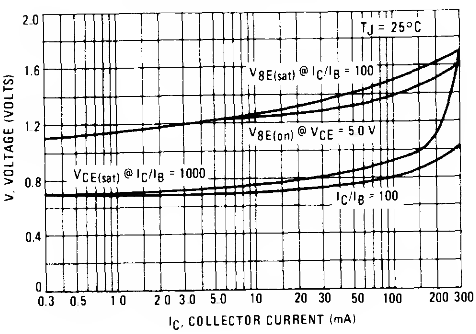


FIGURE 3 – COLLECTOR SATURATION REGION

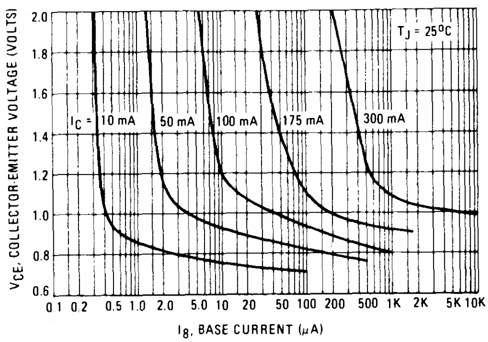


FIGURE 4 – TEMPERATURE COEFFICIENTS

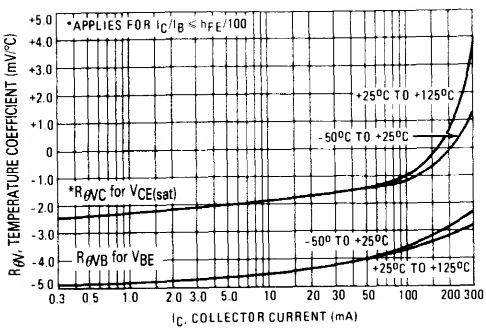


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

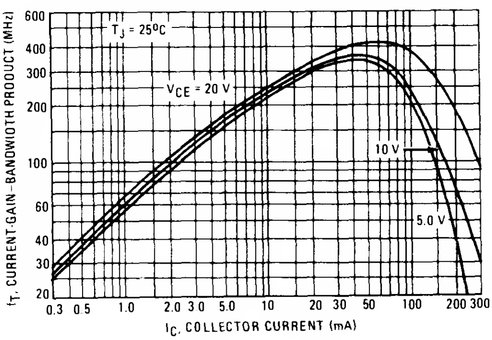


FIGURE 6 — CAPACITANCE

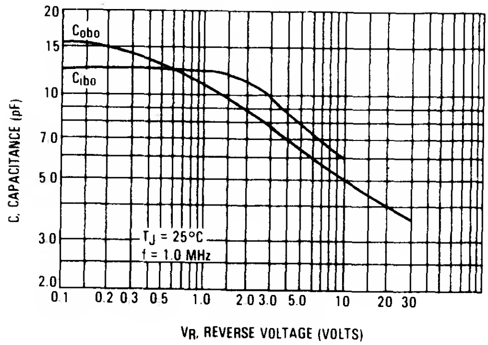
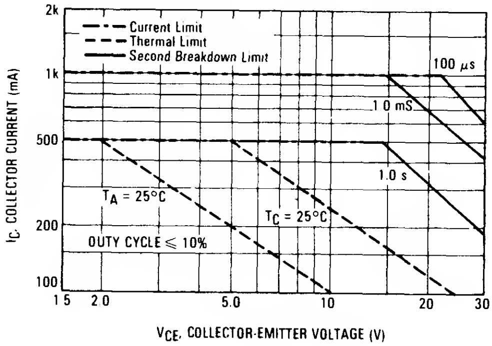


FIGURE 7 — ACTIVE REGION, SAFE OPERATING AREA



MPSW92
MPSW93

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPSW92	MPSW93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	MPSW92 MPSW93	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPSW92 MPSW93	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	MPSW92 MPSW93	I_{CBO}	— —	0.25 0.25	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	Both Types Both Types MPSW92 MPSW93	h_{FE}	25 40 25 25	— — — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	MPSW92 MPSW93	$V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	MPSW92 MPSW93	C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 — D.C. CURRENT GAIN

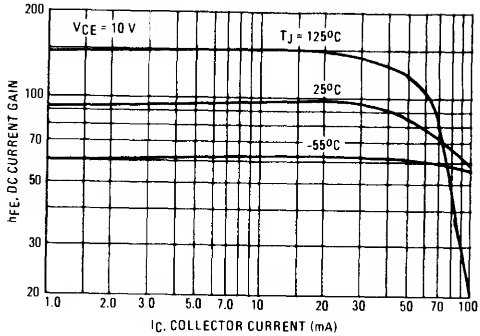


FIGURE 2 — COLLECTOR SATURATION REGION

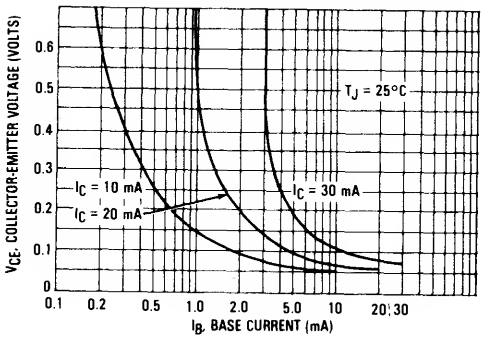


FIGURE 3 — ON VOLTAGES

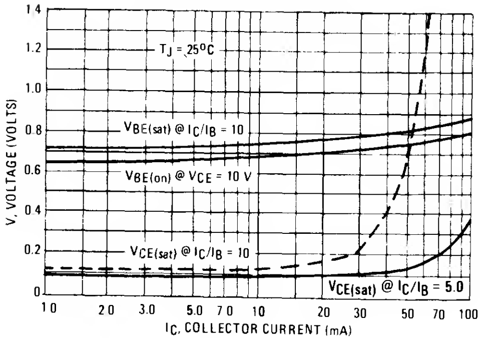


FIGURE 4 — TEMPERATURE COEFFICIENTS

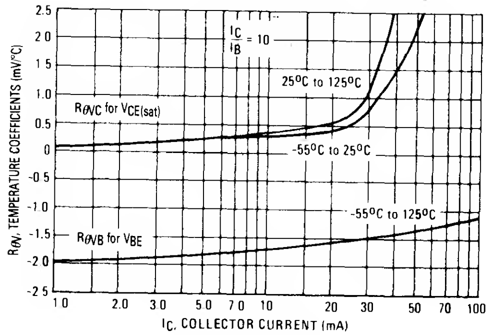


FIGURE 5 — CAPACITANCE

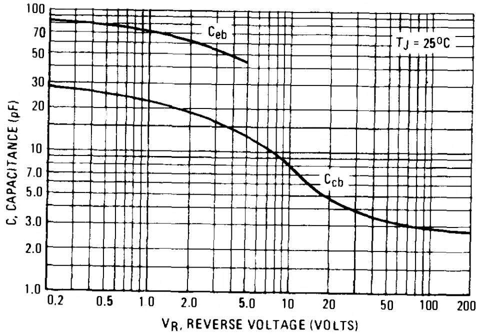


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

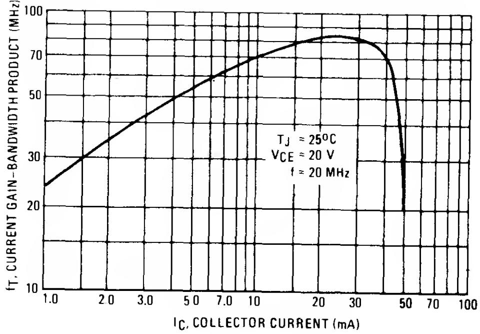
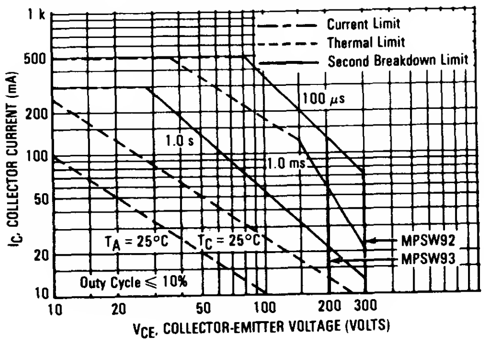


FIGURE 7 — ACTIVE REGION SAFE OPERATING AREA



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MSD6100

CASE 29-02, STYLE 3
TO-92 (TO-226AA)

DUAL SWITCHING DIODE
COMMON CATHODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μsec)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}(1)	−55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Current	I_R			μAdc
(V_R = 100 Vdc)		—	5.0	
(V_R = 50 Vdc)		—	0.1	
(V_R = 50 Vdc, T_A = 125°C)		—	20	
Forward Voltage	V_F			Vdc
(I_F = 1.0 mAdc)		0.55	0.7	
(I_F = 10 mAdc)		0.67	0.82	
(I_F = 100 mAdc)		0.75	1.1	
Capacitance (V_R = 0)	C	—	1.5	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	4.0	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = −65 to +150°C, θ_{JC} = 125°C/W.

MSD6102

CASE 29-02, STYLE 3
TO-92 (TO-226AA)

DUAL DIODE
COMMON CATHODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}(1)	−55 to +135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = −65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	1.0	Vdc
Capacitance (V_R = 0)	C	—	3.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	100	ns

2

MSD6150

CASE 29-02, STYLE 4
TO-92 (TO-226AA)

DUAL DIODE
COMMON ANODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	625 5.0	mW mW°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}(1)	−55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	—	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	—	—	0.1	μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.80	1.0	Vdc
Capacitance (V_R = 0)	C	—	5.0	8.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	—	100	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 8.0 mW/°C, P_D = 10 W @ T_C = 25°C, Derate above 80 mW/°C, T_J, T_{stg} = −55 to +150°, θ_{JC} = 12.5°C/W, θ_{JA} = 125°C.

MVS240

CASE 182-03, STYLE 1
TO-92 (TO-226AA)

24 V STABILIZER

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Operating Current for 24 Vz	I_Z	26	mA
Power Dissipation @ T_A = 25°C	P_D	625	mW
Operating Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.083	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	0.200	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Operating Voltage (I_{ZT} = 5.0 mA)	V_Z	23	24	25	Volts
Operating Voltage Change (I_{ZT} = 5.0 mA, 0 to 70°C)	$\frac{\Delta V_Z}{\Delta T}$	−1.55	−0.20	+1.55	mV/°C
Operating Dynamic Impedance (I_Z = 5.0 mA)	Z_Z	—	9.0	25	Ohms

FIGURE 1 – POWER DERATING

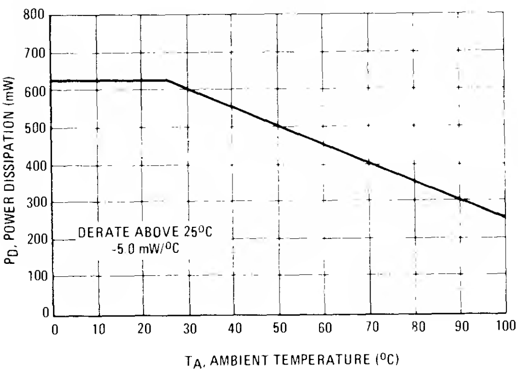

FIGURE 2 – CURRENT DERATING

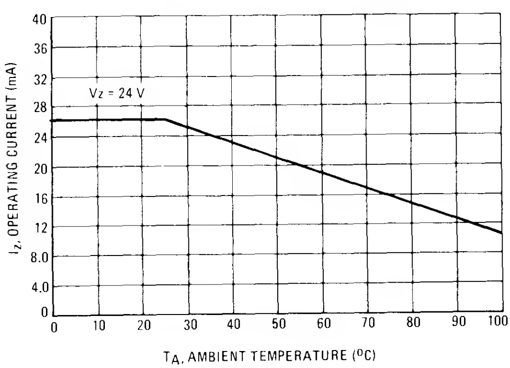

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FIGURE 3 – OPERATING VOLTAGE CHANGE

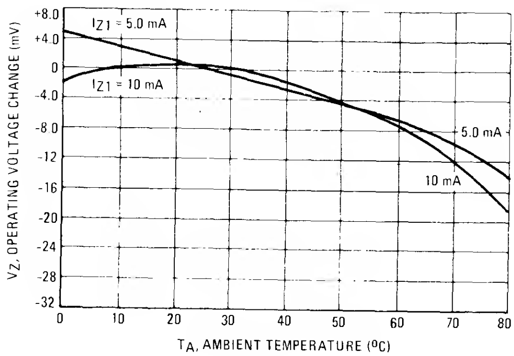


FIGURE 4 – OPERATING VOLTAGE CHANGE TEST CIRCUIT

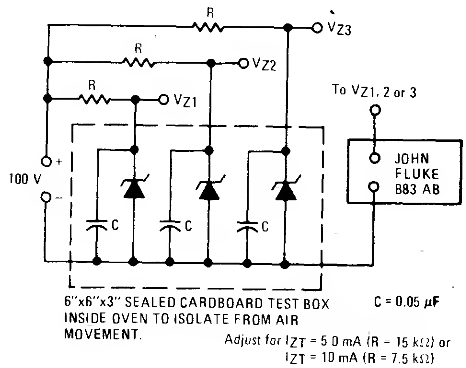


FIGURE 5 – OPERATING IMPEDANCE TEST CIRCUIT

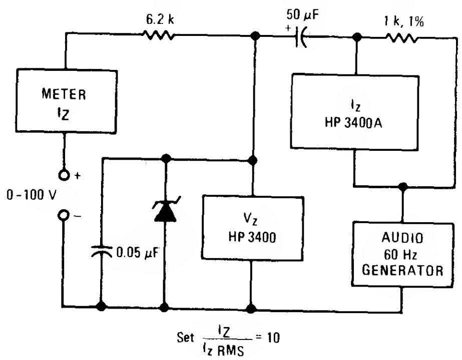
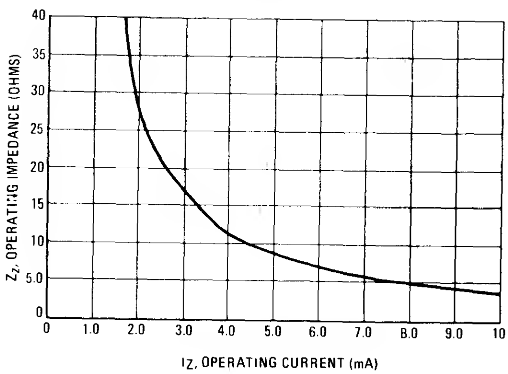


FIGURE 6 – OPERATING IMPEDANCE



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MVS460

CASE 182-01, STYLE 1
TO-92 (TO-226AA)

TUNING DIODE REGULATOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Operating Current for 33 Vz	I_Z	18	mA
Power Dissipation @ T_A = 25°C	P_D	625	mW
Operating Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.083	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	0.200	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Operating Voltage (I_{ZT} = 5.0 mA)	V_Z	31	33	35	Volts
Operating Voltage Change (I_{ZT} = 5.0 mA, 0 to 70°C)	$\frac{\Delta V_Z}{\Delta T}$	−3.1	−2.3	+1.55	mV/°C
Operating Dynamic Impedance (I_Z = 5.0 mA)	Z_z	—	9.0	25	Ohms

FIGURE 1 — POWER DERATING

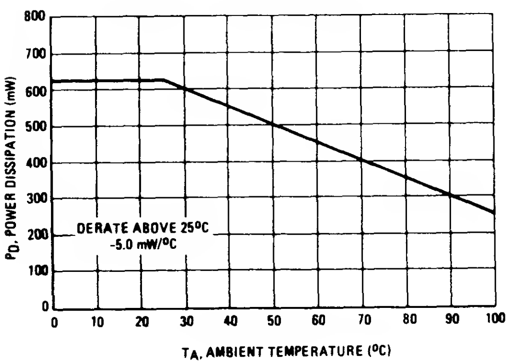


FIGURE 2 — CURRENT DERATING

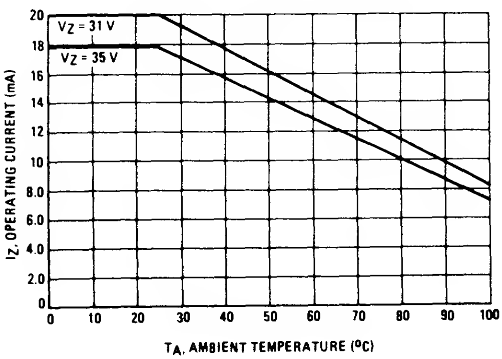


FIGURE 3 – OPERATING VOLTAGE CHANGE

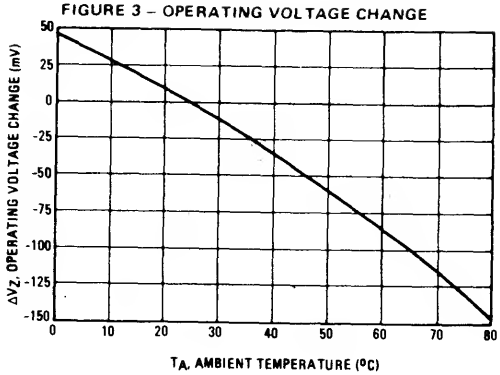


FIGURE 4 – OPERATING VOLTAGE CHANGE TEST CIRCUIT

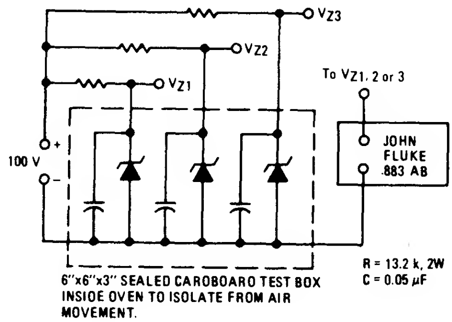


FIGURE 5 – OPERATING IMPEDANCE TEST CIRCUIT

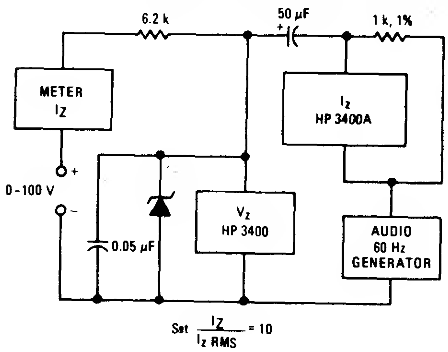
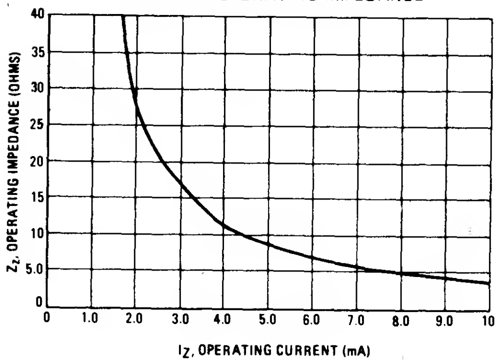


FIGURE 6 – OPERATING IMPEDANCE



PBF259
PBF259S

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	PBF259, S	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	300	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	300	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 250$ Vdc, $I_E = 0$)		I_{CBO}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	 PBF259S All Types All Types	h_{FE}	 60 25 25	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 1.5$ mAdc) ($I_C = 30$ mAdc, $I_B = 60$ mAdc)		$V_{CE(sat)}$	 — —	 0.5 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		f_T	40		MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	3.0	pF

2

PBF259R
PBF259RS

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

NPN SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	PBF259R,RS	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 3.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 250 Vdc, I_E = 0)		I_{CBO}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 20 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	 PBF259RS All Types All Types	h_{FE}	 60 25 25	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 1.5 mAdc) (I_C = 30 mAdc, I_B = 6.0 mAdc)		$V_{CE(sat)}$	 — —	 0.5 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	40	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.0	pF

PBF493
PBF493S

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	PBF493,S	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

Refer to MPSA92 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$)		I_{CBO}	—	0.25	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	 PBF493S All Types All Types	h_{FE}	 40 40 25	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	6.0	pF

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PBF493R
PBF493RS

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTORS

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	PBF493R,RS	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)		I_{CBO}	—	0.25	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	PBF493RS		40	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	All Types		40	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	All Types		25	—	
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF

P2N2222
P2N2222A

CASE 29-02, STYLE 17
TO-39 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

2

Refer to MPS2222 for graphs.

MAXIMUM RATINGS

Rating	Symbol	P2N 2222	P2N 2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current − Continuous	I_C	600		mAdc
Total Device Dissipation $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	P2N2222 P2N2222A	$V_{(BR)CEO}$	30 40	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	P2N2222 P2N2222A	$V_{(BR)CBO}$	60 75	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	P2N2222 P2N2222A	$V_{(BR)EBO}$	5.0 6.0	— —	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	P2N2222A	I_{CEX}	—	10	nAdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	P2N2222 P2N2222A P2N2222 P2N2222A	I_{CBO}	— — — —	0.01 0.01 10 10	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	P2N2222A	I_{EBO}	—	10	nAdc
Base Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	P2N2222A	I_{BEX}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) (1) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc) (1) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc) (1)	 P2N2222A only P2N2222 P2N2222A	h_{FE}	35 50 75 35 100 50 30 40	— — — — 300 — — —	—
Collector-Emitter Saturation Voltage (1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	P2N2222 P2N2222A P2N2222 P2N2222A	$V_{CE(sat)}$	— — — —	0.4 0.3 1.6 1.0	Vdc

P2N2222, P2N2222A

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 P2N2222 P2N2222A P2N2222 P2N2222A	$V_{BE(sat)}$	 — 0.6 — —	 1.3 1.2 2.6 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	 P2N2222 P2N2222A	f_T	 250 300	 — —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	 P2N2222 P2N2222A	C_{ibo}	 — —	 30 25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 P2N2222A P2N2222A	h_{ie}	 2.0 0.25	 8.0 1.25	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 P2N2222A P2N2222A	h_{re}	 — —	 8.0 4.0	$X10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 P2N2222A P2N2222A	h_{fe}	 50 75	 300 375	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 P2N2222A P2N2222A	h_{oe}	 5.0 25	 35 200	μmhos
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	P2N2222A	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	P2N2222A	N_F		4.0	dB
SWITCHING CHARACTERISTICS MPS2222A only					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%. (2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON TIME

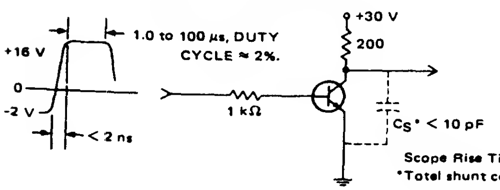
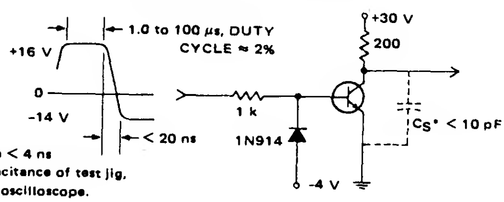


FIGURE 2 – TURN-OFF TIME



Scope Rise Time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope.

P2N2907
P2N2907A

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	P2N 2907	P2N 2907A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current – Continuous	I_C	600		mAdc
Total Device Dissipation $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

Refer to MPS2907 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	P2N2907 P2N2907A	$V_{(BR)CEO}$	40 60	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 0.5 Vdc)		I_{CEX}	—	50	nAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C)	P2N2907 P2N2907A P2N2907 P2N2907A	I_{CBO}	— — — —	0.020 0.010 20 10	μAdc
Base Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 0.5 Vdc)		I_B	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (1) (I_C = 500 mAdc, V_{CE} = 10 Vdc) (1)	P2N2907 P2N2907A P2N2907 P2N2907A P2N2907 P2N2907A P2N2907, P2N2907A P2N2907 P2N2907A	h_{FE}	35 75 50 100 75 100 100 30 50	— — — — — — 300 — —	—
Collector-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	— —	0.4 1.6	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	— —	1.3 2.6	Vdc

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (1), (2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figures 1 and 5)	t_{on}	—	50	ns
Delay Time		t_d	—	10	ns
Rise Rime		t_r	—	40	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_{off}	—	110	ns
Storage Time		t_s	—	80	ns
Fall Time		t_f	—	30	ns

FIGURE 1 – DELAY AND RISE TIME TEST CIRCUIT

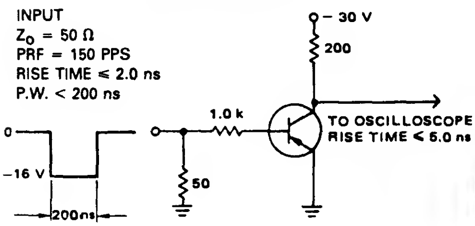
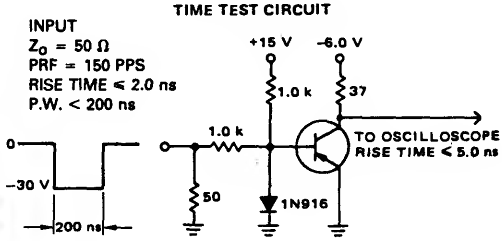


FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT



P2N3019
P2N3020

CASE 29-3, STYLE 1
TO-92 (TO-226AE)

ONE WATT
AMPLIFIER TRANSISTORS

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watts mW/°C
Total Device Dissipation $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 30 mAdc, I_B = 0)		$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = + 150°C)		I_{CBO}	— —	0.01 10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	P2N3020 P2N3019	h_{FE}	50 30	— 100	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	P2N3019 P2N3020		90 40	— 120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	P2N3019 P2N3020		100 40	300 120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc, T_C = − 55 °C)	P2N3019		40	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	P2N3019 P2N3020		50 30	— 100	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	All Types		15	—	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	— —	0.2 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	—	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	P2N3019 P2N3020	f_T	80 100	—	MHz

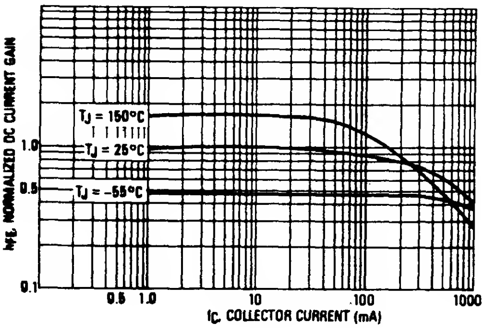
2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25 °C unless otherwise noted.)

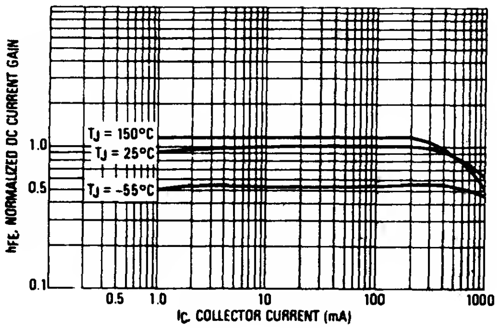
Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	60	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	P2N3019 P2N3020	h_{fe}	80 30	400 200	—
Collector Base Time Constant (I_E = 10 mAdc, V_{CB} = 10 Vdc, f = 4.0 MHz)	P2N3019, P2N3020 P2N3700	$r_b'C_c$	— 15	400 400	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kohms, f = 1.0 kHz)		N_F	—	4	dB

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 1.0%.

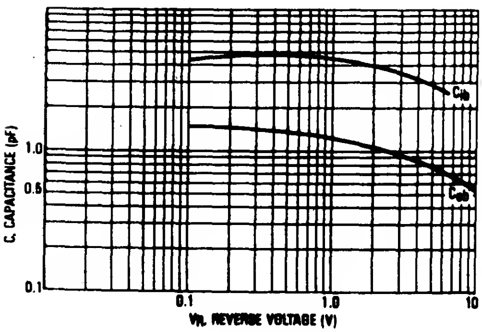
DC CURRENT GAIN
P2N3019



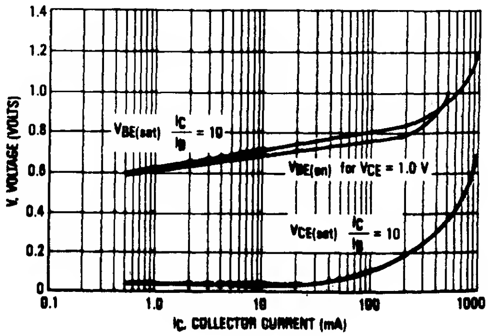
DC CURRENT GAIN
P2N3020



CAPACITANCE



"ON" VOLTAGES



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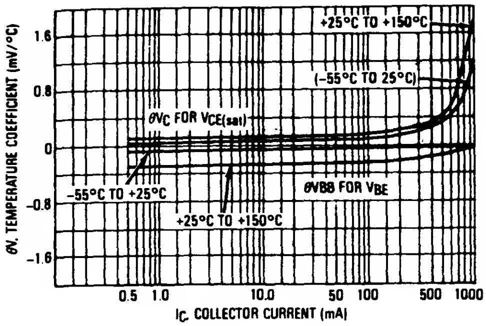
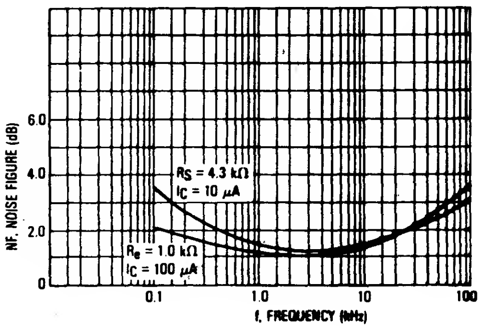
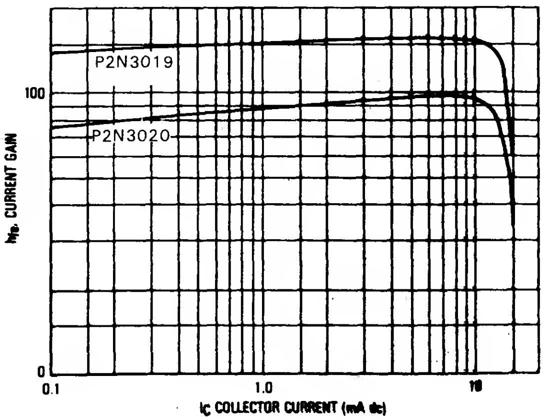
TEMPERATURE COEFFICIENTS



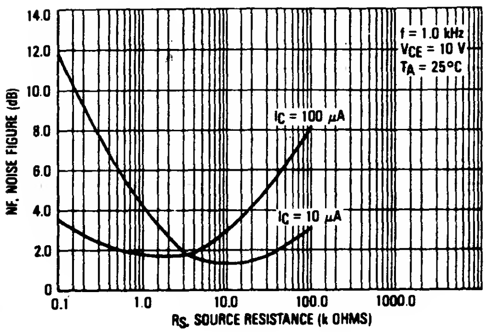
FREQUENCY EFFECTS



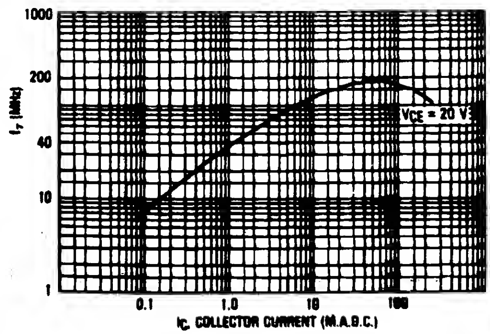
CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT — 1 kHz h_{fe}



SOURCE RESISTANCE EFFECTS



CURRENT GAIN — BANDWIDTH PRODUCT



2

P2N4031
P2N4033

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

ONE WATT
AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	W mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA)		$V_{(BR)CEO}$	80	—	V
Collector-Base Breakdown Voltage (I_C = 10 μA)		$V_{(BR)CBO}$	80	—	V
Emitter-Base Breakdown Voltage (I_E = 10 μA)		$V_{(BR)EBO}$	5.0	—	V
Collector Cutoff Current (V_{CB} = 60 V) (V_{CB} = 60 V, T_A = 150°C)		I_{CBO}	 — —	 5.0 50	nA μA
Emitter Cutoff Current (V_{EB} = 5.0 V)		I_{EBO}	—	10	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mA, V_{CE} = 5.0 V, −55°C)	 P2N4031 P2N4033	h_{FE}	 15 40	 — —	—
(I_C = 100 μA, V_{CE} = 5.0 V)	P2N4031 P2N4033		30 75	— —	
(I_C = 100 mA, V_{CE} = 5.0 V)	P2N4031 P2N4033		40 100	120 300	
(I_C = 500 mA, V_{CE} = 5.0 V)	P2N4031 P2N4033		25 70	— —	
(I_C = 1.0 A, V_{CE} = 5.0 V)	P2N4031 P2N4033		10 25	— —	
Collector-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA) (I_C = 500 mA, I_B = 50 mA)		$V_{CE(sat)}$	 — —	 0.15 0.50	V
Base-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA) (I_C = 500 mA, I_B = 50 mA)		$V_{BE(sat)}$	 — —	 0.9 1.1	V

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CE} = 10 V, f = 1.0 MHz)	C_{obo}	—	25	pF
Input Capacitance (V_{EB} = 0.5 V, f = 1.0 MHz)	C_{ibo}	—	150	pF
Current Gain — Bandwidth Product (I_C = 50 mA, V_{CC} = 10 V, f = 100 MHz)	f_T	150		MHz
SWITCHING CHARACTERISTICS				
Turn-On Time (see Figure 1) (I_C = 500 mA, I_{B1} = 50 mA)	t_{on}	—	100	ns
Turn-Off Time (see Figure 1) (I_C = 500 mA, I_{B1} = I_{B2} = 50 mA)	t_{off}	—	400	ns

(1) Pulse Width = 300 μs, Duty Cycle 1.0%.

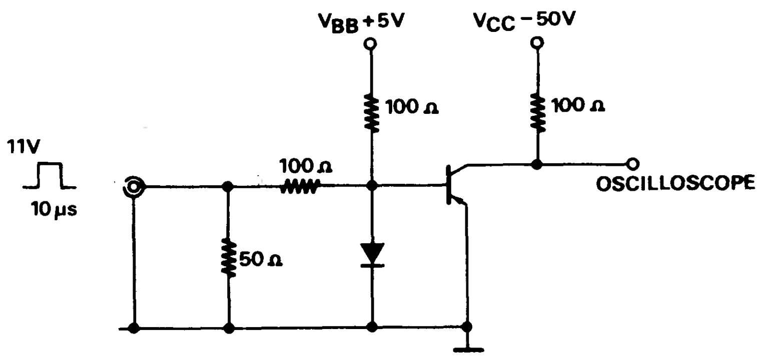


FIGURE 1: SWITCHING TIMES TEST CIRCUIT

P2N5550
P2N5551

CASE 29-02, STYLE 17
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

NPN SILICON

Refer to 2N5550 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N 5550	2N 5551	Unit
Collector-Emitter Voltage	V_{CEO}	140	160	Vdc
Collector-Base Voltage	V_{CBO}	160	180	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current – Continuous	I_C	600		mAdc
Total Device Dissipation $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

(1) $R_{\theta JA}$ is mesured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (2) (I_C = 1.0 mAdc, I_B = 0)	P2N5550 P2N5551	$V_{(BR)CEO}$	140 160	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	P2N5550 P2N5551	$V_{(BR)CBO}$	160 180	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	P2N5550 P2N5551 P2N5550 P2N5551	I_{CBO}	— — — —	100 50 100 50	nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS (2)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	P2N5550 P2N5551 P2N5550 P2N5551 P2N5550 P2N5551	h_{FE}	60 80 60 80 20 30	— — 250 250 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	Both Types P2N5550 P2N5551	$V_{CE(sat)}$	— — —	0.15 0.25 0.20	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	Both Types P2N5550 P2N5551	$V_{BE(sat)}$	— — —	1.0 1.2 1.0	Vdc

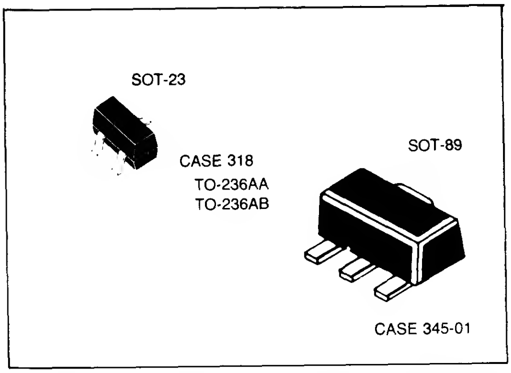
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain − Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	100	300	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	P2N5550	C_{ibo}	—	30	pF
	P2N5551		—	20	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	50	200	—
Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohms, f = 10 Hz to 15.7 kHz)	P2N5550	NF	—	10	dB
	P2N5551		—	8.0	

(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

Microminature Products

3



A wide variety of discrete components from Motorola's repertoire of reliability-proven semiconductor processes and geometries are available in the SOT-23 and SOT-89 packages. Products include Bipolar and Field-Effect Transistors, Switching, Zener and Varactor Diodes.

As an additional service to our customers SOT-23's are available in:

- 8 mm tape and reel
- reverse pinout
- standard profile (TO-236AA) or
  low profile (TO-236AB)

Contact your Motorola representative for ordering information.

3

BAL99

CASE 318-02/03, STYLE 17
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	70	Vdc
Peak Forward Current	I_F	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 70 V) (V_R = 25 V, T_J = 150°C) (V_R = 70 V, T_J = 150°C)	I_R	 — — —	 2.5 30 50	μA
Reverse Breakdown Voltage (I_R = 100 μA)	$V_{(BR)}$	70	—	V
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA) (I_F = 50 mA) (I_F = 100 mA)	V_F	 — — — —	 715 855 1100 1300	mV
Recovery Current (I_F = 10 mA, V_R = 5.0 V, R_L = 500 Ω)	Q_S	—	45	pC
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Reverse Recovery Time (I_F = I_R = 10 mA, R_L = 100 Ω, measured at I_R = 1.0 mA)	t_{rr}	—	6.0	ns
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V

BAS16

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	75	V_{CC}
Peak Forward Current	I_F	200	mA
Peak Forward Surge Current	$I_{FM(surge)}$	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 75 V) (V_R = 75 V, T_J = 150°C) (V_R = 25 V, T_J = 150°C)	I_R	 — — —	 1.0 50 30	µA
Reverse Breakdown Voltage (I_{BR} = 100 µA)	$V_{(BR)}$	75	—	V
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA) (I_F = 50 mA) (I_F = 100 mA)	V_F	 — — — —	 715 855 1100 1300	mV
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	2.0	pF
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V
Reverse Recovery Time (I_F = I_R = 10 mA, R_L = 100 Ω)	t_{rr}	—	6.0	ns
Stored Charge (I_F = 10 mA to V_R = 5.0 V, R_L = 500 Ω)	Q_S	—	45	pC

3

BAV70

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

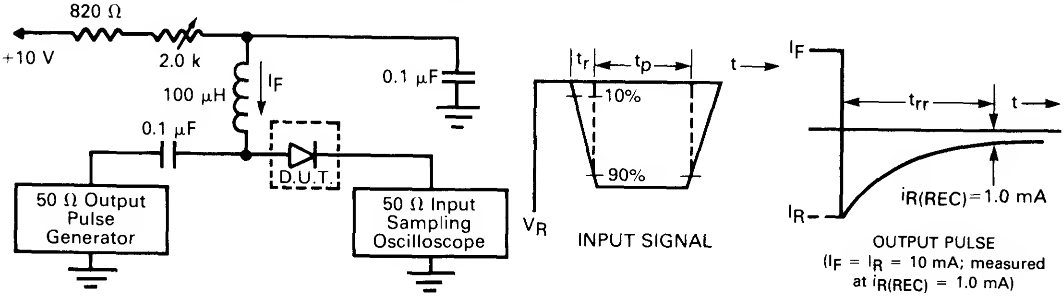
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	>70	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc) (V_R = 70 Vdc, T_J = 150°C)	I_R	 — — —	 60 5.0 100	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_T	—	1.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 100 mAdc)	V_F	 — — — —	 715 855 1100 1300	mVdc
Reverse Recovery Time (I_F = i_R = 10 mAdc, V_R = 5.0 Vdc, $I_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	6.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

BAV74

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 5.0 μAdc)	$V_{(BR)}$	50	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc, T_J = 125°C) (V_R = 50 Vdc)	I_R	 — —	 100 0.1	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_T	—	2.0	pF
Forward Voltage (I_F = 100 mAdc)	V_F	—	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc, measured at I_R = 1.0 mA, R_L = 100 Ω)	t_{rr}	—	4.0	ns

3

BAV99

CASE 318-02/03, STYLE 11
SOT-23 (TO-236AA/AB)

DUAL SERIES SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	100	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

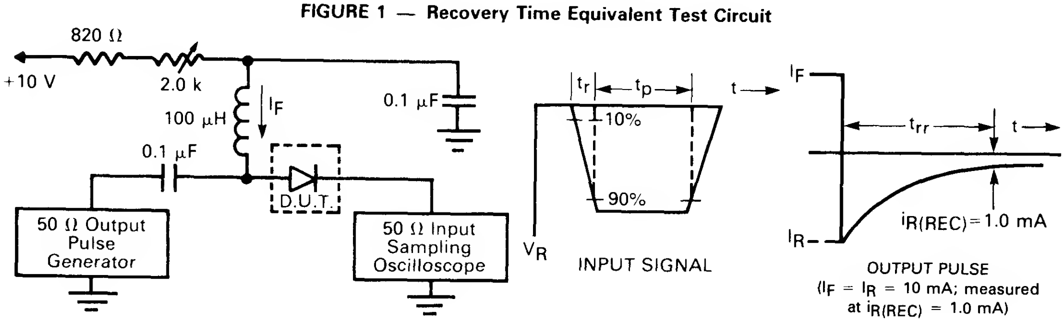
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μA)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc) (V_R = 70 Vdc, T_J = 150°C)	I_R	 — — —	 30 2.5 50	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_T	—	1.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 100 mAdc)	V_F	 — — — —	 715 855 1100 1300	mVdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	6.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

BAW56

CASE 318-02/03, STYLE 12
SOT-23 (TO-236AA/AB)

DUAL SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	200	mAdc

THERMAL CHARACTERISTICS

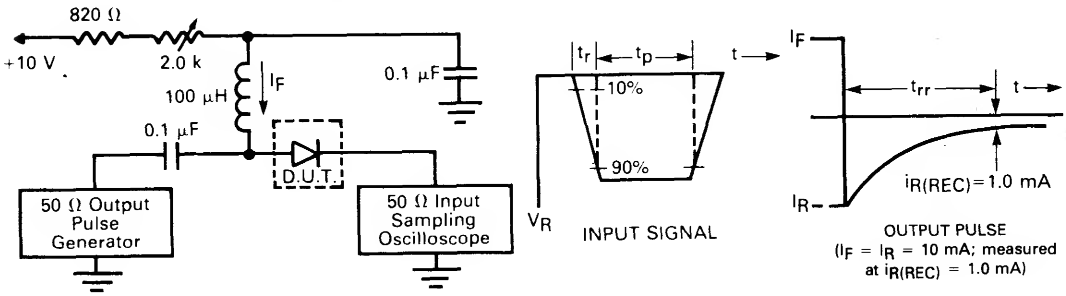
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc) (V_R = 70 Vdc, T_J = 150°C)	I_R	 — — —	 30 2.5 50	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_T	—	2.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 100 mAdc)	V_F	 — — — —	 715 855 1100 1300	mVdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $I_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	6.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. t_p » t_{rr}

3

BCW29,30

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 2.0$ mAdc, $I_E = 0$)		$V_{(BR)CEO}$	20	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{EB} = 0$)		$V_{(BR)CES}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_C = 0$)		$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 100°C$)		I_{CBO}	 — —	 100 10	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)	 BCW29 BCW30	h_{FE}	 120 215	 260 500	 — —
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	0.6	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($I_E = 0$, $V_{CE} = 10$ Vdc, f = 1.0 MHz)		C_{obo}	—	7.0	pF
Noise Figure ($I_C = 0.2$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 2.0$ kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	10	dB

BCW31,32,33

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_B = 0)		$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCW31 BCW32 BCW33	h_{FE}	110 200 420	220 450 800	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.55	0.70	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (I_E = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	10	dB

3

BCW60A,B,C,D

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	Vdc
Collector-Base Voltage	V_{CBO}	32	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)		$V_{(BR)CEO}$	32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc) (V_{CE} = 32 Vdc, T_A = 150°C)		I_{GES}	— —	20 20	nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	BCW60A BCW60B BCW60C BCW60D	h_{FE}	— 20 40 100	— — — —	—
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCW60A BCW60B BCW60C BCW60D		120 180 250 380	220 310 460 630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCW60A BCW60B BCW60C BCW60D		60 70 90 100	— — — —	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BCW60A BCW60B BCW60C BCW60D		125 175 250 350	250 350 500 700	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 10 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	— —	0.55 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 50 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	0.7 0.6	1.05 0.85	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.55	0.75	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1.0 MHz)	C_{obo}	—	4.5	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R_1 = R_2 = 5.0 kΩ, R_L = 990 Ω)	t_{off}	—	800	ns

3

BCW61A,B,C,D

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	Vdc
Collector-Base Voltage	V_{CBO}	32	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc) (V_{CE} = 32 Vdc, T_A = 150°C)		I_{CES}	 — —	 20 20	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	 BCW61A BCW61B BCW61C BCW61D	h_{FE}	 — 20 40 100	 — — — —	—
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCW61A BCW61B BCW61C BCW61D		120 140 250 380	220 310 460 630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCW61A BCW61B BCW61C BCW61D		60 80 100 100	— — — —	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BCW61A BCW61B BCW61C BCW61D		125 175 250 350	250 350 500 700	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 10 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	 — —	 0.55 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 10 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	 0.68 0.6	 1.05 0.85	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.6	0.75	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R_1 = R_2 = 5.0 kΩ, R_L = 990 Ω)	t_{off}	—	800	ns

BCW65A,B,C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	32	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{EB} = 0)		$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc, I_E = 0) (V_{CE} = 32 Vdc, I_E = 0, T_A = 150°C)		I_{CES}	 — —	 — —	 20 20	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}	—	—	—	—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	A		35	—	—	—
	B		50	—	—	—
	C		80	—	—	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	A		75	—	—	—
	B		110	—	—	—
	C		180	—	—	—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	A		100	—	250	—
	B		160	—	400	—
	C		250	—	630	—
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc			35	—	—	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	 — —	 — —	 0.7 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	—	—	2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	—	80	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	—	10	dB

SWITCHING CHARACTERISTICS

Turn-On Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, R_L = 150 Ω)	t_{on}	—	—	100	ns
Turn-Off Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, R_L = 150 Ω)	t_{off}	—	—	400	ns

3

BCW66F,G

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{EB} = 0)		$V_{(BR)CES}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 45 Vdc, I_C = 0) (V_{CE} = 45 Vdc, I_C = 0, T_A = 150°C)		I_{CES}	 — —	 — —	 20 20	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}	—	—	—	—
(I_C = 100 μAdc, V_{CE} = 1.0 Vdc)	F		35	—	—	—
	G		50	—	—	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	F		75	—	—	—
	G		110	—	—	—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	F		100	—	250	—
	G		160	—	400	—
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc			35	—	—	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	 — —	 — —	 0.7 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	100	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	—	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	—	80	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	—	10	dB
SWITCHING CHARACTERISTICS						
Turn-On Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, R_L = 150 Ω)		t_{on}	—	—	100	ns
Turn-Off Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, R_L = 150 Ω)		t_{off}	—	—	400	ns

BCW67,A,B,C
BCW68,F,G

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	BCW67	BCW68	Unit
Collector-Emitter Voltage	V_{CEO}	32	45	Vdc
Collector-Base Voltage	V_{CBO}	45	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	800		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BCW67 Series BCW68 Series	$V_{(BR)CEO}$	32 45	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{EB} = 0)	BCW67 Series BCW68 Series	$V_{(BR)CES}$	45 60	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc, I_E = 0) (V_{CE} = 45 Vdc, I_E = 0) (V_{CE} = 32 Vdc, I_B = 0, T_A = 150°C) (V_{CE} = 45 Vdc, I_B = 0, T_A = 150°C)	BCW67 Series BCW68 Series BCW67 Series BCW68 Series	I_{CES}	— — — —	— — — —	20 20 10 10	nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	BCW67,A,68,F BCW67B,68G BCW67C	h_{FE}	75 120 180	— — —	— — —	—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	BCW67,A,68,F BCW67B,68G BCW67C		100 160 250	— — —	250 400 630	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	BCW67,A,68,F BCW67B,68G BCW67C		35 60 100	— — —	— — —	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	—	—	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	100	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	—	18	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	—	80	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	—	10	dB

3

BCW69,70

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	45	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 0)		$V_{(BR)CES}$	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 100°C)		I_{CBO}	— —	100 10	nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCW69 BCW70	h_{FE}	120 215	260 500	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.6	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (I_E = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{obo}	—	7.0	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	10	dB

BCW71,72

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, V_{EB} = 0)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, V_{EB} = 0)	$V_{(BR)CES}$	45	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 — —	 100 10	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc) BCW71 BCW72	h_{FE}	110 200	— —	220 450	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	 — —	 — 0.21	 0.25 —	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{BE(sat)}$	—	0.85	—	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	0.6	—	0.75	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 35 MHz)	f_T	—	300	—	MHz
Output Capacitance (I_E = 0, V_{CE} = 10 Vdc, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1.0 MHz)	C_{ibo}	—	9.0	—	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	—	10	dB

3

BCX17,18

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		BCX17	BCX18	
Collector-Emitter Voltage	V_{CEO}	45	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BCX17 BCX18	$V_{(BR)CEO}$	45 25	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, I_C = 0)	BCX17 BCX18	$V_{(BR)CES}$	50 30	— —	— —	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	— —	— —	100 5.0	nAdc μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	—	10	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 300 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	100 70 40	— — —	600 — —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	—	—	0.62	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	—	1.2	Vdc

BCX19,20

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value BCX19	Value BCX20	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	BCX19 BCX20	$V_{(BR)CEO}$	45 25	— —	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $I_C = 0$)	BCX19 BCX20	$V_{(BR)CES}$	50 30	— —	— —	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 150°C$)		I_{CBO}	— —	— —	100 5.0	nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	10	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 300$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	100 70 40	— — —	600 — —	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	—	—	0.62	Vdc
Base-Emitter On Voltage ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	—	1.2	Vdc

3

BCX51
BCX52
BCX53

CASE 345-01, STYLE 1
SOT-89

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BCX51	BCX52	BCX53	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	V
Collector-Emitter Voltage	V_{CER}	45	60	100	V
Collector-Base Voltage	V_{CBO}	45	60	100	V
Emitter-Base Voltage	V_{EBO}	5.0	5.0	5.0	V
Base Current	I_B	0.1	0.1	0.1	A
Collector Current — Continuous	I_C	1.0	1.0	1.0	A
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA) (I_C = 10 mA) (I_C = 10 mA)	 BCX51 BCX52 BCX53	$V_{(BR)CEO}$	 45 60 80	 — — —	V
Collector-Base Breakdown Voltage (I_C = 10 μA) (I_C = 10 μA) (I_C = 10 μA)	 BCX51 BCX52 BCX53	$V_{(BR)CBO}$	 45 60 100	 — — —	V
Emitter-Base Breakdown Voltage (I_E = 10 μA)		$V_{(BR)EBO}$	5.0	—	V
Collector Cutoff Current (V_{CB} = 30 V) (V_{CB} = 30 V, T_J = 125°C)		I_{CBO}	 — —	 100 10	 nA μA
Emitter Cutoff Current (V_{EB} = 3.0 V)		I_{EBO}	—	100	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mA, V_{CE} = 2.0 V) (I_C = 150 mA, V_{CE} = 2.0 V) (I_C = 150 mA, V_{CE} = 2.0 V) (I_C = 500 mA, V_{CE} = 2.0 V)	 BCX51 BCX52,53	h_{FE}	 25 40 40 25	 — 250 160 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mA, I_B = 50 mA)		$V_{CE(sat)}$	—	0.5	V
Base-Emitter On Voltage (I_C = 500 mA, V_{CE} = 2.0 V)		$V_{BE(on)}$	—	1.0	V
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 5.0 V, I_C = 10 mA, f = 35 MHz)		f_T	50	—	MHz

BCX54
BCX55
BCX56

CASE 345-01, STYLE 1
SOT-89

GENERAL PURPOSE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	BCX54	BCX55	BCX56	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	V
Collector-Emitter Voltage	V_{CER}	45	60	100	V
Collector-Base Voltage	V_{CBO}	45	60	100	V
Emitter-Base Voltage	V_{EBO}	5.0	5.0	5.0	V
Base Current	I_B	0.1	0.1	0.1	A
Collector Current — Continuous	I_C	1.0	1.0	1.0	A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA) (I_C = 10 mA) (I_C = 10 mA)	 BCX54 BCX55 BCX56	$V_{(BR)CEO}$	 45 60 80	 — — —	V
Collector-Base Breakdown Voltage (I_C = 10 μA) (I_C = 10 μA) (I_C = 10 μA)	 BCX54 BCX55 BCX56	$V_{(BR)CBO}$	 45 60 100	 — — —	V
Emitter-Base Breakdown Voltage (I_E = 500 mA, I_B = 50 mA) (I_E = 10 μA) (I_E = 10 μA)	 BCX54 BCX55 BCX56	$V_{(BR)EBO}$	 5.0 5.0 5.0	 — — —	V
Collector Cutoff Current (V_{CB} = 30 V) (V_{CB} = 30 V, T_J = 125°C)		I_{CBO}	 — —	 100 10	 nA μA
Emitter Cutoff Current (V_{EB} = 3.0 V)		I_{EBO}	—	100	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mA, V_{CE} = 2.0 V) (I_C = 150 mA, V_{CE} = 2.0 V) (I_C = 500 mA, V_{CE} = 2.0 V)		h_{FE}	 25 40 25	 — 250 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mA, I_B = 50 mA)		$V_{CE(sat)}$	—	0.5	V
Base-Emitter On Voltage (I_C = 500 mA, V_{CE} = 2.0 V)		$V_{BE(on)}$	—	1.0	V
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 5.0 V, I_C = 10 mA, f = 35 MHz)		f_T	50	—	MHz

3

BCX68

CASE 345-01, STYLE 1
SOT-89

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	V
Collector-Emitter Voltage	V_{CES}	25	V
Emitter-Base Voltage	V_{EBO}	5.0	V
Base Current	I_B	100	mA
Base Current — Maximum	I_{BM}	200	mA
Collector Current — Continuous	I_C	1.0	A
Collector Current — Maximum	I_{CM}	2.0	A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	20	—	V
Collector Cutoff Current ($V_{CB} = = 25$ V)	I_{CBO}	—	100	nA
Emitter Cutoff Current ($V_{EB} = 5.0$ V)	I_{EBO}	—	10	μA
ON CHARACTERISTICS				
DC Current Gain ($V_{CE} = 10$ V, $I_C = 5.0$ mA) ($V_{CE} = 1.0$ V, $I_C = 0.5$ A) ($V_{CE} = 1.0$ V, $I_C = 1.0$ A)	h_{FE}	 50 85 60	 — 375 —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ A, $I_B = 100$ mA)	$V_{CE(sat)}$	—	0.5	V
Base-Emitter On Voltage ($V_{CE} = 10$ V, $I_C = 5.0$ mA) ($V_{CE} = 1.0$ V, $I_C = 1.0$ A)	$V_{BE(on)}$	 — —	 0.6 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($V_{CE} = 5.0$ V, $I_C = 10$ mA, f = 20 MHz)	f_T	65	—	MHz

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	V
Collector-Emitter Voltage	V_{CES}	25	V
Emitter-Base Voltage	V_{EBO}	5.0	V
Base Current	I_B	100	mA
Base Current — Maximum	I_{BM}	200	mA
Collector Current — Continuous	I_C	1.0	A
Collector Current — Maximum	I_{CM}	2.0	A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

BCX69

CASE 345-01, STYLE 1
SOT-89

GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	20	—	V
Collector Cutoff Current (V_{CB} = 25 V)	I_{CBO}	—	100	nA
Emitter Cutoff Current (V_{EB} = 5.0 V)	I_{EBO}	—	10	μA
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA) (V_{CE} = 1.0 V, I_C = 0.5 A) (V_{CE} = 1.0 V, I_C = 1.0 A)	h_{FE}	 50 85 60	 — 375 —	—
Collector-Emitter Saturation Voltage (I_C = 1.0 A, I_B = 100 mA)	$V_{CE(sat)}$	—	0.5	V
Base-Emitter On Voltage (V_{CE} = 10 V, I_C = 5.0 mA) (V_{CE} = 1.0 V, I_C = 1.0 A)	$V_{BE(on)}$	 — —	 0.6 1.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 5.0 V, I_C = 10 mA, f = 20 MHz)	f_T	65	—	MHz

3

BCX70G,H,J,K

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)		$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc) (V_{CE} = 32 Vdc, T_A = 150°C)		I_{CES}	 — —	 20 20	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	 BCX70G BCX70H BCX70J BCX70K	h_{FE}	 — 20 40 100	 — — — —	—
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCX70G BCX70H BCX70J BCX70K		120 180 250 380	220 310 460 630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCX70G BCX70H BCX70J BCX70K		60 70 90 100	— — — —	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 10 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	 — —	 0.55 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 50 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	 0.7 0.6	 1.05 0.85	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.55	0.75	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1.0 MHz)		C_{obo}	—	4.5	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BCX70G	h_{fe}	125	250	—
	BCX70H		175	350	
	BCX70J		250	500	
	BCX70K		350	700	
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	6.0	dB
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R1 = R2 = 5.0 kΩ, R_L = 990 Ω)		t_{off}	—	800	ns

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3

BCX71G,H,J,K

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc) (V_{CE} = 32 Vdc, T_A = 150°C)		I_{CES}	 — —	 20 20	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	 BCX71G BCX71H BCX71J BCX71K	h_{FE}	 — 30 40 100	 — — — —	—
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCX71G BCX71H BCX71J BCX71K		120 140 250 380	220 310 460 630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCX71G BCX71H BCX71J BCX71K		60 80 100 110	— — — —	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BCX71G BCX71H BCX71J BCX71K		125 175 250 350	250 350 500 700	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.25 mAdc) (I_C = 50 mAdc, I_B = 1.25 mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.55	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.25 mAdc) (I_C = 50 mAdc, I_B = 1.25 mAdc)		$V_{BE(sat)}$	 0.6 0.68	 0.85 1.05	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.6	0.75	Vdc
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R1 = R2 = 5.0 kΩ, R_L = 990 Ω)	t_{off}	—	800	ns

3

BFQ17

CASE 345-01, STYLE 1
SOT-89

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	V
Collector-Emitter Voltage ($R_{BE} \leq 50\ \Omega$)	V_{CER}	40	V
Collector-Base Voltage	V_{CBO}	40	V
Emitter-Base Voltage	V_{EBO}	2.0	V
Collector Current — Continuous	I_C	300	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	25	—	V
Collector-Base Breakdown Voltage (I_C = 10 μA)	$V_{(BR)CBO}$	40	—	V
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	2.0	—	V
Collector Cutoff Current (V_{CB} = 20 V) (V_{CB} = 20 V, T_A = 150°C)	I_{CBO}	 — —	 100 20	nA
Emitter Cutoff Current (V_{EB} = 1.0 V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mA, V_{CE} = 5.0 V) (I_C = 150 mA, V_{CE} = 5.0 V)	h_{FE}	 25 25	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)	$V_{CE(sat)}$	—	0.5	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 15 V, I_C = 150 mA, f = 500 MHz)	f_T	1200(1)	—	MHz
Collector-Base Capacitance (V_{CB} = 15 V, f = 1.0 MHz)	C_{cb}	—	4.0	pF
Reverse Transfer Capacitance Common-Emitter (V_{CE} = 15 V, I_C = 10 mA, f = 1.0 MHz)	C_{re}	—	1.9	pF

(1) Typical only

BFQ18A

CASE 354-01, STYLE 1
SOT-89

RF TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	V
Collector-Base Voltage	V_{CBO}	25	V
Emitter-Base Voltage	V_{EBO}	12	V
Collector Current — Continuous	I_C	150	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	15	—	V
Collector-Base Breakdown Voltage (I_C = 10 μA)	$V_{(BR)CBO}$	25	—	V
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	2.0	—	V
Collector Cutoff Current (V_{CB} = 10 V)	I_{CBO}	—	100	nA
Emitter Cutoff Current (V_{EB} = 1.0 V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mA, V_{CE} = 10 V) (I_C = 100 mA, V_{CE} = 10 V)	h_{FE}	 25 25	 — —	—
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 10 V, I_C = 50 mA, f = 500 MHz)	f_T	3200(1)	—	MHz

(1) Typical only

3

BFQ19

CASE 345-01, STYLE 1
SOT-89

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	V
Collector-Base Voltage	V_{CBO}	20	V
Emitter-Base Voltage	V_{EBO}	3.0	V
Collector Current Max (f > 1.0 MHz)	I_{CM}	150	mA
Collector Current — Average	I_{CAV}	75	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	15	—	V
Collector-Base Breakdown Voltage (I_C = 10 μA)	$V_{(BR)CBO}$	20	—	V
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	3.0	—	V
Collector Cutoff Current (V_{CB} = 10 V)	I_{CBO}	—	100	nA
Emitter Cutoff Current (V_{EB} = 1.0 V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mA, V_{CE} = 10 V) (I_C = 75 mA, V_{CE} = 10 V)	h_{FE}	 25 25	 — —	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 500 MHz) (I_C = 75 mA, V_{CE} = 10 V, f = 500 MHz)	f_T	 4.0 4.4	 — —	GHz
Collector-Base Capacitance (V_{CB} = 10 V, f = 1.0 MHz)	C_{cb}	—	1.6	pF
Capacitance Emitter-to-Base (V_{EB} = 0.5 V, f = 1.0 MHz)	C_{eb}	—	5.0	pF
Reverse Transfer Capacitance Common Emitter (V_{CE} = 10 V, I_C = 10 mA, f = 1.0 MHz)	C_{re}	—	1.3	pF
Noise Figure (I_C = 50 mA, V_{CE} = 10 V, f = 500 MHz)	NF	—	3.3	dB

BFR30,31

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

JFET
AMPLIFIER

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate Reverse Current (V_{GS} = 10 Vdc, V_{DS} = 0)		I_{GSS}	—	0.2	nAdc
Gate Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 10 Vdc)	BFR30 BFR31	$V_{GS(off)}$	— —	5.0 2.5	Vdc
Gate Source Voltage (I_D = 1.0 mAdc, V_{DS} = 10 Vdc)	BFR30 BFR31	V_{GS}	0.7 —	3.0 1.3	Vdc
(I_D = 50 μAdc, V_{DS} = 10 Vdc)	BFR30 BFR31		— —	4.0 2.0	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V_{DS} = 10 Vdc, V_{GS} = 0)	BFR30 BFR31	I_{DSS}	4.0 1.0	10 5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 kHz)	BFR30 BFR31	$\|Y_{fs}\|$	1.0 1.5	4.0 4.5	mAdc
(I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 kHz)	BFR30 BFR31		0.5 0.75	— —	
Output Admittance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 kHz) (I_D = 200 μAdc, V_{DS} = 10 Vdc)	BFR31 BFR31	$\|Y_{os}\|$	40 20	25 15	μAdc
Input Capacitance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 MHz) (I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 MHz)		C_{iss}	— —	5.0 4.0	pF
Reverse Transfer Capacitance (I_D = 1.0 mAdc, V_{DS} = 10 Vdc, f = 1.0 MHz) (I_D = 200 μAdc, V_{DS} = 10 Vdc, f = 1.0 MHz)		C_{rss}	— —	1.5 1.5	pF

3

BFR92,S

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	25	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mA)		$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μA)		$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA)		$V_{(BR)EBO}$	2.0	—	Vdc
Collector Cutoff Current (V_{CE} = 10 V)		I_{CEO}	—	50	nA
Collector Cutoff Current (V_{CB} = 10 V)		I_{CBO}	—	50	nA
Emitter Cutoff Current (V_{EB} = 1.0 V)		I_{EBO}	—	10	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 μA, V_{CE} = 10 V) (I_C = 3.0 mA, V_{CE} = 1.5 V) (I_C = 14 mA, V_{CE} = 10 V)(1)	 BFR92S 	h_{FE}	 25 30 25	 — 100 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 25 mA, I_B = 5.0 mA)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 25 mA, I_B = 5.0 mA)		$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 14 mA, V_{CE} = 10 V, f = 500 MHz)		f_T	4.5	—	MHz
Noise Figure (V_{CE} = 1.5 V, I_C = 3.0 mA, R_S = 50 Ω, f = 30 MHz)	BFR92S	NF	—	3.0	dB

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BFR93,S

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	25	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA)		$V_{(BR)CEO}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μA)		$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA)		$V_{(BR)EBO}$	2.0	—	Vdc
Collector Cutoff Current (V_{CE} = 10 V)		I_{CEO}	—	50	nA
Collector Cutoff Current (V_{CB} = 10 V)		I_{CBO}	—	50	nA
Emitter Cutoff Current (V_{EB} = 1.0 V)		I_{EBO}	—	10	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mA, V_{CE} = 5.0 V) (I_C = 20 mA, V_{CE} = 4.0 V) (I_C = 30 mA, V_{CE} = 5.0 V)	BFR93S	h_{FE}	 25 30 25	 — 100 —	—
Collector-Emitter Saturation Voltage (I_C = 35 mA, I_B = 7.0 mA)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 35 mA, I_B = 7.0 mA)		$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 30 mA, V_{CE} = 5.0 V, f = 500 MHz)		f_T	4.5	—	GHz
Noise Figure (V_{CE} = 5.0 V, I_C = 2.0 mA, R_S = 50 Ω, f = 30 MHz)	BFR93S	NF	—	3.0	dB

3

BFS17,S

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)		$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μA)		$V_{(BR)CBO}$	25	—	Vdc
Collector Cutoff Current ($V_{CE} = 10$ V)		I_{CEO}	—	25	nA
Collector Cutoff Current ($V_{CB} = 15$ V)		I_{CBO}	—	25	nA
Emitter Cutoff Current ($V_{EB} = 1.0$ V)		I_{EBO}	—	10	nA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0$ mA, $V_{CE} = 1.0$ V) ($I_C = 2.0$ mA, $V_{CE} = 1.0$ V) ($I_C = 25$ mA, $V_{CE} = 1.0$ V)	 BFS17 BFS17S 	h_{FE}	 20 50 20	 150 150 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)		$V_{CE(sat)}$	—	0.4	V
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)		$V_{BE(sat)}$	—	1.0	V
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 2.0$ mA, $V_{CE} = 5.0$ V, f = 500 MHz) ($I_C = 25$ mA, $V_{CE} = 5.0$ V, f = 500 MHz)		f_T	 1.0 1.3	 — —	GHz
Output Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)		C_{obo}	—	1.5	pF
Noise Figure ($I_C = 2.0$ mA, $V_{CE} = 5.0$ V, $R_S = 50\ \Omega$, f = 30 MHz)	BFS17S	NF	—	5.0	dB

BSS63

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Emitter Voltage R_{BE} = 10 kΩ	V_{CER}	110	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc)	$V_{(BR)CEO}$	100	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, I_E = 0, R_{BE} = 10 kΩ)	$V_{(BR)CER}$	110	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	110	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Collector Cutoff Current (V_{CE} = 110 Vdc, R_{BE} = 10 kΩ)	I_{CER}	—	—	10	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	I_{EBO}	—	—	200	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 25 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 30	 — —	 — —	—
Collector-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	—	—	250	mVdc
Base-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)	$V_{BE(sat)}$	—	—	900	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 25 mAdc, V_{CE} = 5.0 Vdc, f = 35 MHz)	f_T	50	95	—	MHz
Case Capacitance (I_E = I_C = 0, V_{CB} = 10 Vdc)	C_C	—	—	5.0	pF

3

BSS64

CASE 318-03, STYLE 6
SOT-23 (TO-236AA/AB)

DRIVER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 4.0 mA)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 80 V, T_A = 70°C)	I_{CES}	—	20	μA
Emitter Cutoff Current (V_{BE} = 4.0 V)	I_{EBO}	—	200	nA
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = 1.0 V, I_C = 10 mA)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 4.0 mA, I_B = 400 μA) (I_C = 50 mA, I_B = 15 mA)	$V_{CE(sat)}$	 — —	 0.7 3.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mA, V_{CE} = 10 V, f = 35 MHz)	f_T	50	—	MHz

BSS79B,C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc)		$V_{(BR)CBO}$	75	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc) (V_{CB} = 60 Vdc, T_A = 150°C)		I_{CBO}	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc)		I_{EBO}	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc)	B C	h_{FE}	40 100	120 300	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	 — —	 0.3 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 MHz)		f_T	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{obo}	—	8.0	pF
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 30 Vdc, I_C = 150 mAdc) (I_{B1} = I_{B2} = 15 mAdc)		t_d	—	10	ns
Rise Time (V_{CC} = 30 Vdc, I_C = 150 mAdc) (I_{B1} = I_{B2} = 15 mAdc)		t_r	—	10	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 150 mAdc) (I_{B1} = I_{B2} = 15 mAdc)		t_s	—	225	ns
Fall Time (V_{CC} = 30 Vdc, I_C = 150 mAdc) (I_{B1} = I_{B2} = 15 mAdc)		t_f	—	60	ns

3

BSS80B,C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu A$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc) ($V_{CB} = 50$ Vdc, $T_A = 150°C$)		I_{CBO}	 — —	 10 10	 nA μA
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc)		I_{EBO}	—	10	nA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 150$ mA, $V_{CE} = 10$ Vdc)	B C	h_{FE}	40 100	120 300	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA) ($I_C = 500$ mA, $I_B = 50$ mA)		$V_{CE(sat)}$	 — —	 0.4 1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mA, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)		C_{obo}	—	8.0	pF
SWITCHING CHARACTERISTICS					
Delay Time	($I_{B1} \approx I_{B2} \approx 15$ mA, $V_{CC} = 30$ V, $I_C = 150$ mA)	t_d	—	10	ns
Rise Time		t_r	—	40	ns
Storage Time	($I_{B1} \approx I_{B2} \approx 15$ mA, $V_{CC} = 30$ V, $I_C = 150$ mA)	t_s	—	80	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BSS82C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μA)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μA)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ V) ($V_{CB} = 50$ V, $T_A = 150°C$)	I_{CBO}	 — —	 10 10	 nA μA
Emitter Cutoff Current ($V_{EB} = 3.0$ V)	I_{EBO}	—	10	nA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 150$ mA, $V_{CE} = 10$ V)	h_{FE}	100	300	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA) ($I_C = 500$ mA, $I_B = 50$ mA)	$V_{CE(sat)}$	 — —	 0.4 1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mA, $V_{CE} = 20$ V, f = 200 MHz)	f_T	100	—	MHz

3

BSV52

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	20	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derete above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermel Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc)	$V_{(BR)CEO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$) ($V_{CB} = 10$ Vdc, $I_E = 0$, $T_A = 125°C$)	I_{CBO}	 — —	 100 5.0	 nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	 25 40 25	 — 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 300$ μAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	 — — —	 300 250 400	mVdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	 700 —	 850 1200	mVdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	f_T	400	—	MHz
Output Cepacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{EB} = 1.0$ Vdc, $I_C = 0$)	C_{ibo}	—	4.5	pF
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = I_B = I_{BM} = 10$ mAdc)	t_s	—	13	ns
Turn-On Time ($V_{BE} = 1.5$ Vdc, $I_C = 10$ mAdc, $I_B = 3.0$ mAdc)	t_{on}	—	12	ns
Turn-Off Time ($I_C = 10$ mAdc, $I_B = 3.0$ mAdc)	t_{off}	—	18	ns

BSX39

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	14	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 2.0 mA)	$V_{(BR)CEO}$	14	—	Vdc
Collector Cutoff Current (V_{CB} = 12 V)	I_{CBO}	—	100	nA
Collector Cutoff Current (V_{CE} = 12 V) (V_{CE} = 12 V, T_J = 125°C)	I_{CES}	— —	100 5.0	nA μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mA, V_{CE} = 1.0 V) (I_C = 10 mA, V_{CE} = 1.0 V) (I_C = 50 mA, V_{CE} = 1.0 V)	h_{FE}	25 40 25	— 200 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA) (I_C = 50 mA, I_B = 5.0 mA)	$V_{CE(sat)}$	— —	250 400	mV
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA) (I_C = 50 mA, I_B = 5.0 mA)	$V_{BE(sat)}$	700 —	850 1.2	mV V
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mA, I_B = 3.0 mA)	t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mA, I_{B1} = I_{B2} = 3.0 mA)	t_{off}	—	18	ns

3

MMBD101

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

HOT-CARRIER
UHF MIXER DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)}$	4.0	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 3.0 Vdc)	I_R	—	—	0.25	μAdc
Series Inductance (f = 250 MHz)	L_S	—	6.0	—	nH
Case Capacitance (f = 1.0 MHz)	C_C	—	0.18	—	pF
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_T	—	—	1.0	pF
Forward Voltage (I_F = 10 mAdc)	V_F	—	—	0.60	Vdc
Noise Figure (f = 1.0 GHz)	NF	—	—	7.0	dB

MMBD352

CASE 318-02/03 STYLE 11
SOT-23 (TO-236AA/AB)

DUAL HOT CARRIER MIXER DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	4	V_{CC}

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Forward Voltage ($I_F = 10$ mA)	V_F	—	0.60	V
Reverse Voltage Leakage Current ($V_R = 3.0$ V) ($V_R = 4.0$ V)	I_R	 — —	 0.25 10	μA
Capacitance ($V_R = 0$ V, f = 1.0 MHz)	C	—	1.0	pF

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MMBD501

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

HOT-CARRIER DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)}$	50	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc)	I_R	—	—	200	μAdc
Diode Capacitance (V_R = 20 Vdc, f = 1.0 MHz)	C_T	—	—	1.0	pF
Forward Voltage (I_F = 10 mAdc)	V_F	—	—	1.2	Vdc

MMBD914

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

HIGH-SPEED SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

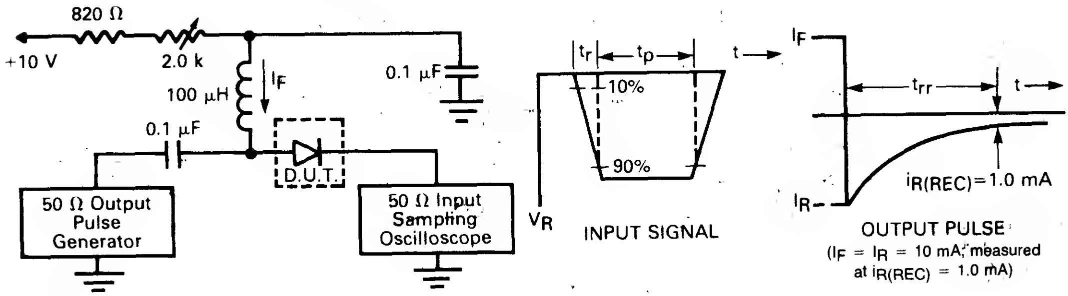
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage (I_R = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current (V_R = 20 Vdc) (V_R = 75 Vdc)	I_R	 — —	 25 5.0	 nAdc μAdc
Diode Capacitance (V_R = 0 Vdc, f = 1.0 MHz)	C_T	—	4.0	pF
Forward Voltage (I_F = 10 mAdc)	V_F	—	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc) (Figure 1)	t_{rr}	—	4.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MMBD2835,36

CASE 318-02/03, STYLE 12
SOT-23 (TO-236AA/AB)

DUAL
SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	100	mAdc

THERMAL CHARACTERISTICS

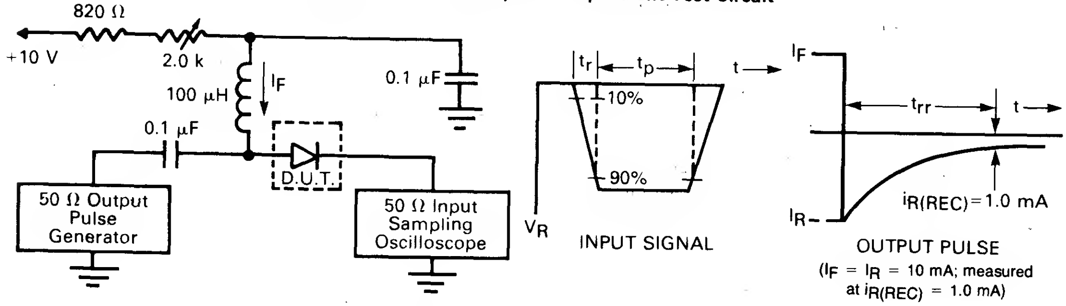
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 100\ \mu Adc$)	 MMBD2835 MMBD2836	$V_{(BR)}$	 35 75	 — —	Vdc
Reverse Voltage Leakage Current ($V_R = 30$ Vdc) ($V_R = 50$ Vdc)	 MMBD2835 MMBD2836	I_R	 — —	 100 100	nAdc
Diode Capacitance ($V_R = 0$, f = 1.0 MHz)		C_T	—	4.0	pF
Forward Voltage ($I_F = 10$ mAdc) ($I_F = 50$ mAdc) ($I_F = 100$ mAdc)		V_F	 — — —	 1.0 1.0 1.2	Vdc
Reverse Recovery Time ($I_F = I_R = 10$ mAdc, $i_{R(REC)} = 1.0$ mAdc) (Figure 1)		t_{rr}	—	6.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MMBD2837
MMBD2838

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

DUAL SWITCHING DIODE

3

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Peak Reverse Voltage		V_{RM}	75	Vdc
D.C. Reverse Voltage	MMBD2837 MMBD2838	V_R	30 50	Vdc
Peak Forward Current		I_{FM}	450 300	mAdc
Average Rectified Current		I_O	150 100	mAdc

THERMAL CHARACTERISTICS

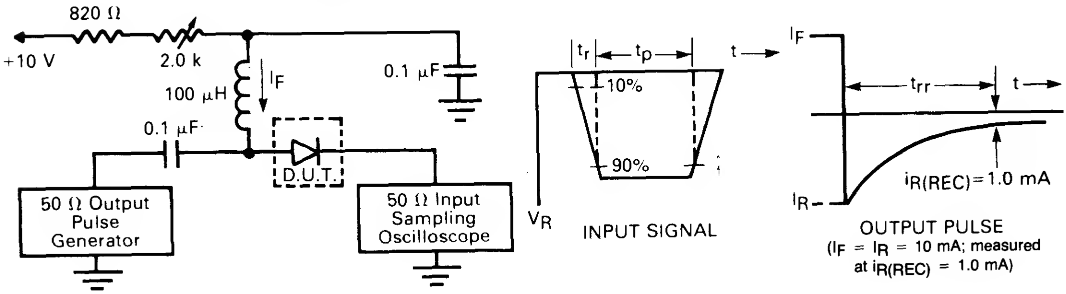
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	MMBD2837 MMBD2838	$V_{(BR)}$	35 75	— —	Vdc
Reverse Voltage Leakage Current (V_R = 30 Vdc) (V_R = 50 Vdc)	MMBD2837 MMBD2838	I_R	— —	0.1 0.1	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)		C_T	—	4.0	pF
Forward Voltage (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 100 mAdc)		V_F	— — —	1.0 1.0 1.2	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)		t_{rr}	—	6.0	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

3

MMBD6050

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

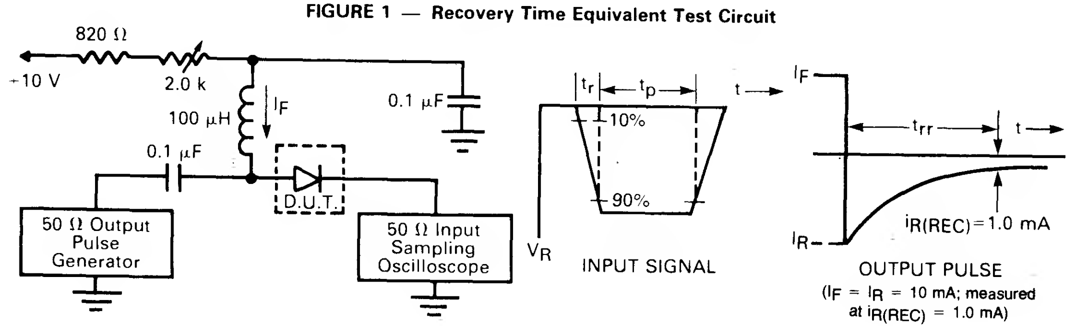
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 100 mAdc)	V_F	 0.55 0.85	 0.7 1.1	Vdc
Reverse Recovery Time ($I_F = I_R$ = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	10	ns
Capacitance (V_R = 0)	C	—	2.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MMBD6100

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

DUAL SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

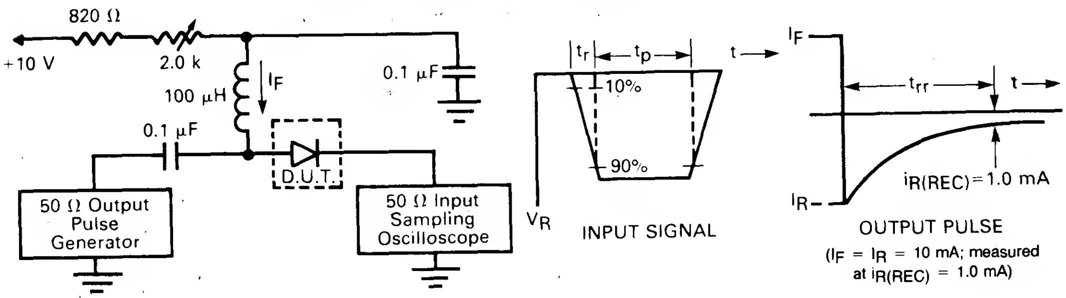
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 100 mAdc)	V_F	 0.55 0.85	 0.7 1.1	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	15	ns
Capacitance (V_R = 0)	C	—	2.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

3

MMBD7000

CASE 318-02/03, STYLE 11
SOT-23 (TO-236AA/AB)

DUAL
SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Forward Current	I_F	200	mAdc
Peak-Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

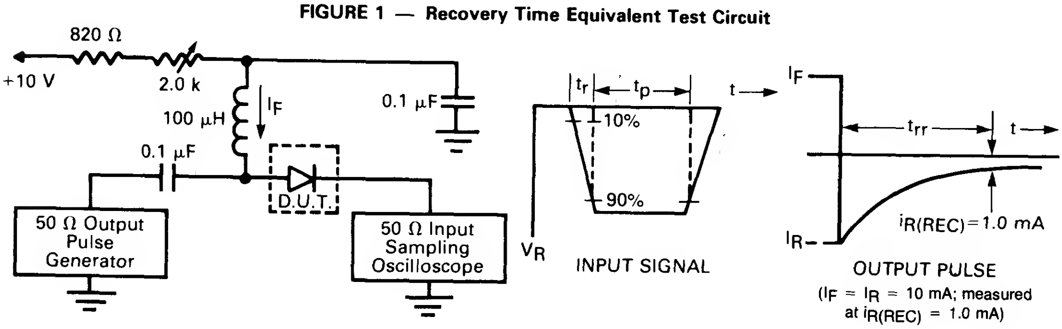
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc) (V_R = 100 Vdc) (V_R = 50 Vdc, 125°C)	 I_R I_{R2} I_{R3}	 — — —	 0.30 0.5 100	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 100 mAdc)	V_F	 0.55 0.67 0.75	 0.7 0.82 1.1	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc) (Figure 1)	t_{rr}	—	15	ns
Capacitance (V_R = 0)	C	—	1.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. t_p » t_{rr}

MMBF4391
thru
MMBF4393

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

JFET
SWITCHING TRANSISTOR

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 25°C) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	— —	1.0 0.20	nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	MMBF4391 MMBF4392 MMBF4393	$V_{GS(off)}$	4.0 2.0 0.5	10 5.0 3.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V_{DS} = 15 V, V_{GS} = 0)	MMBF4391 MMBF4392 MMBF4393	I_{DSS}	50 25 5.0	150 75 30	mAdc
Drain Current (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 15, V_{GS} = 12 Vdc, T_A = 100°C)		I_D	— —	1.0 1.0	nAdc μAdc
Drain-Source On-Voltage (I_D = 12 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 3.0 mAdc, V_{GS} = 0)	MMBF4391 MMBF4392 MMBF4393	$V_{DS(on)}$	— — —	0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	MMBF4391 MMBF4392 MMBF4393	$r_{DS(on)}$	— — —	30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	14	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)		C_{rss}	—	3.5	pF

3

MMBF4416

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
VHF/UHF AMPLIFIER TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)	I_{GSS}	— —	100 200	pAdc nAdc
Gate Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	—	6.0	Vdc
Gate Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	V_{GS}	1.0	5.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain (V_{GS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	15	mAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert Y_{fs} \rvert$	4500	7500	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert Y_{os} \rvert$	—	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	0.8	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, $R_g \approx$ 1000 Ω, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, $R_g \approx$ 1000 Ω, f = 400 MHz)	NF	— —	2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 400 MHz)	G_{ps}	18 10	— —	dB

MMBF4860

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
SWITCHING TRANSISTOR

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

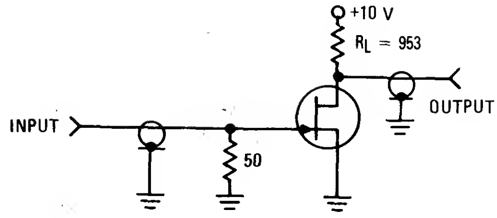
*Package mounted on 99.5% alumina 10 x x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

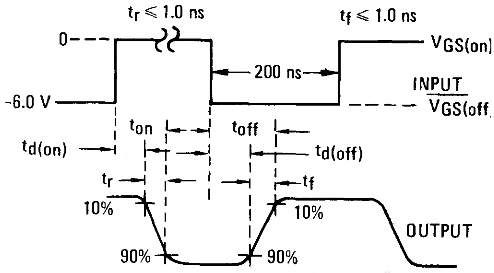
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)	I_{GSS}	 — —	 0.5 2.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	$V_{GS(off)}$	2.0	6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	20	100	mAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 10 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 10 Vdc, T_A = 150°C)	$I_{D(off)}$	 — —	 0.25 0.5	 nAdc μAdc
Drain-Source On-Voltage (I_D = 10 mAdc, V_{GS} = 0)	$V_{DS(on)}$	—	0.5	Vdc
Static Drain-Source On Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{DS(on)}$	—	40	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{iss}	—	18	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{rss}	—	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc) ($V_{G(on)}$ = 0, $V_{GS(off)}$ = 10 Vdc)	t_d	—	6.0	ns
Rise Time (V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc) ($V_{GS(on)}$ = 0, $V_{GS(off)}$ = 6.0 Vdc) (Figure 1)	t_r	—	4.0	ns
Turn-Off Time (V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc) ($V_{GS(on)}$ = 0, $V_{GS(off)}$ = 4.0 Vdc) (Figure 1)	t_{off}	—	50	ns

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: 1. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 ohms, Duty Cycle ≈ 2.0%

2. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 0.75$ ns, $R_{in} \geq 1.0$ megohm, $C_{in} \leq 2.5$ pF.

MMBF5457

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
GENERAL PURPOSE TRANSISTOR

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}	 — —	 — —	 1.0 200	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	$V_{GS(off)}$	0.5	—	6.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 100 μAdc)	V_{GS}	—	2.5	—	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	1.0	—	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	1000	—	5000	μmhos
Reverse Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{rs}\|$	—	10	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.5	3.0	pF

(1) Pulse test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

3

MMBF5459

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	−25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −10 μA, V_{DS} = 0)	$V_{(BR)GSS}$	25	—	Vdc
Gate 1 Leakage Current (V_{GS} = −15 V, V_{DS} = 0)	I_{G1SS}	—	1.0	nA
Gate 2 Leakage Current (V_{GS} = −15 V, V_{DS} = 0, T_A = 100°C)	I_{G2SS}	—	200	nA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)	$V_{GS(off)}$	2.0	8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain (V_{DS} = 15 V, V_{GS} = 0)	I_{DSS}	4.0	16	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	2000	6000	μmhos
Output Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{os}\|$	—	50	μmhos
Input Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	3.0	pF

MMBF5460

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
GENERAL PURPOSE
TRANSISTOR

P-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	I_{GF}	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	40	—	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}	 — —	 — —	 5.0 1.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	0.75	—	6.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.1 mAdc)	V_{GS}	0.5	—	4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	1.0	—	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	1000	—	4000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{os}\|$	—	—	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.0	2.0	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 MΩ, f = 100 Hz, BW = 1.0 Hz)	$\bar{e}_n$	—	20	—	$nV/\sqrt{Hz}$

3

MMBF5484

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mA
Continuous Device Dissipation at or Below $T_C = 25°C$ Linear Derating Factor	P_D	200 2.80	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu A$, $V_{DS} = 0$)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current ($V_{GS} = -20$ V, $V_{DS} = 0$) ($V_{GS} = -20$ V, $V_{DS} = 0$, $T_A = 100°C$)	I_{GSS}	— —	−1.0 −0.2	nA μA
Gate Source Cutoff Voltage ($V_{DS} = 15$ V, $I_D = 10$ nA)	$V_{GS(off)}$	−0.3	−3.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain ($V_{DS} = 15$ V, $V_{GS} = 0$)	I_{DSS}	1.0	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 kHz)	$\|Y_{fs}\|$	3000	6000	μmhos
Output Admittance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 kHz)	$\|Y_{os}\|$	—	50	μmhos
Input Capacitance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Output Capacitance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 15$ V, $I_D = 1.0$ mA, YG′ = 1.0 mmhos) ($R_G = 1.0$ kΩ, f = 100 MHz) ($V_{DS} = 15$ V, $V_{GS} = 0$, YG′ = 1.0 μmho) ($R_G = 1.0$ MΩ, f = 1.0 kHz)	NF	— —	3.0 2.5	dB
Common Source Power Gain ($V_{DS} = 15$ Vdc, $I_D = 1.0$ mAdc, f = 100 MHz)	G_{ps}	16	25	dB

MMBF5486

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET TRANSISTOR

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (V_{DS} = 0, I_G = −1.0 μA)	$V_{(BR)GSS}$	−25	—	Vdc
Gate 1 Leakage Current (V_{GS} = −20 V, V_{DS} = 0)	I_{G1SS}	—	−1.0	nA
Gate 2 Leakage Current (V_{GS} = −20 V, V_{DS} = 0, T_A = 100°C)	I_{G2SS}	—	−0.2	μA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)	$V_{GS(off)}$	−2.0	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain (V_{GS} = 0, V_{DS} = 15 V)	I_{DSS}	8.0	20	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 kHz)	$\|y_{fs}\|$	4000	8000	μmhos
Input Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{is})$	—	1000	μmhos
Output Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 kHz)	$\|y_{os}\|$	—	75	μmhos
Output Conductance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{os})$	—	100	μmhos
Forward Transconductance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{fs})$	3500	—	μmhos
Input Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Output Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 V, I_D = 4.0 mA, f = 100 MHz, Y_G = 1.0 μmhos) (V_{DS} = 15 V, I_D = 4.0 mA, R_G = 1.0 kΩ, f = 400 MHz, Y_G = 1.0 μmhos) (V_{GS} = 0, V_{DS} = 15 V, R_G = 1.0 mΩ, f = 1.0 kHz, Y_G = 1.0 μmhos)	NF	 — — —	 2.0 4.0 2.5	dB
Common Source Power Gain (V_{DS} = 15 V, I_D = 4.0 mA, f = 100 MHz) (V_{DS} = 15 V, I_D = 4.0 mA, f = 400 MHz)	G_{ps}	 18 10	 30 20	dB

MMBFJ310

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
VHF/UHF AMPLIFIER
TRANSISTOR

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 V) (V_{GS} = −15 V, T_A = 125°C)	I_{GSS}	 — —	 — —	 −1.0 −1.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 nAdc)	$V_{GS(off)}$	−2.0	—	−6.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	24	—	60	mAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	$\|Y_{fs}\|$	8.0	—	18	mmhos
Output Admittance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	$\|Y_{os}\|$	—	—	200	μmhos
Input Capacitance (V_{GS} = −10 Vdc, V_{DS} = 0 Vdc, f = 1.0 MHz)	C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{GS} = −10 Vdc, V_{DS} = 0 Vdc, f = 1.0 MHz)	C_{rss}	—	—	2.5	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 100 Hz)	$\bar{e}_n$	—	10	—	$nV/\sqrt{Hz}$

MMBFU310

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
TRANSISTOR

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu A$, $V_{DS} = 0$)	$V_{(BR)GSS}$	−25	—	Vdc
Gate 1 Leakage Current ($V_{GS} = -15$ V, $V_{DS} = 0$)	I_{G1SS}	—	−150	pA
Gate 2 Leakage Current ($V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 125°C$)	I_{G2SS}	—	−150	nA
Gate Source Cutoff Voltage ($V_{DS} = 10$ V, $I_D = 1.0$ nA)	$V_{GS(off)}$	−2.5	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain ($V_{DS} = 10$ V, $V_{GS} = 0$)	I_{DSS}	24	60	mA
Gate-Source Forward Voltage ($I_G = 10$ mA, $V_{DS} = 0$)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 1.0 kHz)	$\lvert Y_{fs} \rvert$	10	18	mmhos
Output Admittance ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 1.0 kHz)	$\lvert Y_{os} \rvert$	—	150	μmhos
Input Capacitance ($V_{GS} = -10$ V, $V_{DS} = 10$ V, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{GS} = -10$ V, $V_{DS} = 10$ V, f = 1.0 MHz)	C_{rss}	—	2.5	pF

MMBPU131

CASE 318-02/03, STYLE 14
SOT-23 (TO-236AA/AB)

UNIJUNCTION TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation Derate Above 25°C	P_D $R_{\theta JA}$	350 2.8	mW mW/°C
DC Gate Current	I_G	±20	mA
Repetitive Peak Forward Current 100 μs Pulse Width, 1.0% Duty Cycle 20 μs Pulse Width, 1.0% Duty Cycle	I_{TRM}	 1.0 1.0	Amp
Non-Repetitive Peak Forward Current 10 μs Pulse Width	I_{TSM}	1.0	Amp
Gate to Cathode Forward Voltage	V_{GKF}	40	Volt
Gate to Cathode Reverse Voltage	V_{GKR}	5.0	Volt
Gate to Anode Reverse Voltage	V_{GAR}	40	Volt
Anode to Cathode Voltage	V_{AK}	±40	Volt

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Peak-Point Current (V_S = 10 Vdc, R_G = 1.0 MΩ) (V_S = 10 Vdc, R_G = 10 kΩ)	I_P	 — —	 2.0 5.0	μA
On-State Voltage (V_S = 10 Vdc, R_G = 1.0 MΩ)	V_T	0.2	1.6	Volts
Luminous Intensity (V_S = 10 Vdc, R_G = 1.0 MΩ) (V_S = 10 Vdc, R_G = 10 kΩ)	I_V	 — 70	 50 —	μA
Anode to Cathode On-State Voltage (I_F = 50 mA Peak)	V_F	—	1.5	Volts
Output Voltage (V_B = 20 Vdc, C_C = 0.2 μF)	V_O	6.0	—	Volts
Rise Time (V_B = 20 Vdc, C_C = 0.2 μF)	t_r	—	80	ns

MMBR901

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	30	200	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	1.0	pF
Common-Emitter Amplifier Power Gain (V_{CC} = 6.0 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)	G_{pe}(1)	16 (Typ)	—	dB
Noise Figure (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 GHz)	NF(1)	—	1.9 (Typ)	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50Ω system.

3

MMBR920

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER/SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	35	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 14 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	250	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 14 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	1.0	pF
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	NF(1)	 — —	 2.4 3.0	 — —	dB
Common-Emitter Amplifier Power Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	G_{pe}(1)	 — —	 15 10	 — —	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	35	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

MMBR930

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AMPLIFIER/SWITCHING TRANSISTOR

NPN SILICON

3

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	25	—	250	—
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	1.0	pF
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 GHz)	NF(1)	 — —	 1.9 2.5	 — —	dB
Common-Emitter Amplifier Power Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz)	G_{pe}(1)	 — —	 11 8.0	 — —	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

3

MMBR931

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CBO}	10	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	5.0	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 0.1$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	5.0	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	10	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 5.0$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	30	—	150	—
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 1.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	—	0.5	pF
Noise Figure ($I_E = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc, f = 1.0 GHz)	NF(1)	—	4.3	—	dB
Gate Power Dissipation ($I_E = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc, f = 1.0 GHz)	PG(1)	—	10	—	—

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MMBR2060

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	14	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	14	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0, I_C = 0)	I_{EBO}	—	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 500 MHz)	h_{FE}	 20 2.0	 — —	—
Collector-Emitter Saturation Voltage (I_C = 80 mAdc, I_B = 8.0 mAdc)	$V_{CE(sat)}$	—	0.38	Vdc
Base-Emitter Saturation Voltage (I_C = 40 mAdc, I_B = 20 mAdc)	$V_{BE(sat)}$	—	0.98	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 1.0 Vdc, f = 100 MHz)	f_T	—	1.0	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{cb}	—	1.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0)	C_{eb}	—	3.0	pF
Noise Figure (V_{CE} = 10 Vdc, I_E = 1.5 mAdc, f = 450 MHz)	NF(1)	—	3.5	dB
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_E = 1.5 mAdc, f = 450 Mhz)	G_{pe}(1)	12.5	—	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

3

MMBR2857

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	40	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	0.05	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	30	—	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	1000	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 0.1 MHz)	C_{cb}	—	1.0	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 1.0 kHz)	h_{fe}	50	—	—
Noise Figure ($I_C = 1.5$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 50\ \Omega$, f = 450 MHz)	NF	—	4.5	dB
Common-Emitter Amplifier Power Gain ($I_C = 1.5$ mAdc, $V_{CE} = 6.0$ Vdc, f = 450 MHz)	G_{PE}	12.5	—	dB

MMBR4957

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_C = 0)	I_{CBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	150	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_E = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	1,200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.8	pF
Common-Emitter Amplifier Power Gain(1) (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz)	G_{pe}	17 (Typ)	—	dB
Noise Figure(1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	NF	—	3.0 (Typ)	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

3

MMBR5031

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	20	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	10	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)	I_{CBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	h_{FE}	25	300	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	1,000	—	MHz
Collector-Base Capacitance (V_{CE} = 6.0 Vdc, I_E = 0, f = 0.1 MHz)	C_{cb}	—	1.5	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	NF(1)	—	2.5	dB
Common-Emitter Amplifier Power Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	G_{pe}(1)	14	25	dB

(1) Noise figure and power gain measure on Ailtech 7380 50 Ω system.

MMBR5179

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	0.02	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	900	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	—	1.0	pF
Small Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	25	—	—
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 Ω, f = 200 Mhz)	NF(1)	—	4.5	dB
Common-Emitter Amplifier Power Gain (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	G_{pe}(1)	15	—	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

3

MMBS5060,61,62

CASE 318-02/03, STYLE 14
SOT-23 (TO-236AA/AB)

SILICON CONTROLLED RECTIFIER

PNPN DEVICE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Forward Current Avg. (T_C = +67°C)	I_F	510	mA
Peak Forward Gate Voltage	V_{GFM}	5.0	V
Peak Forward Blocking Voltage; RG = 1.0 k MMBS5060 / MMBS5061 / MMBS5062	V_{FXM}	30 / 60 / 100	V

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate Trigger Voltage (R_L = 100 Ω, R_{GC} = 1.0 kΩ, T_C = 125°C)	Anode Voltage = MMBS5060 = 30 V MMBS5061 = 60 V MMBS5062 = 100 V	V_{GNT}	0.1	—	V
Peak Forward Blocking Current (R_{GC} = 1.0 kΩ, T_C = 125°C)	V_{FXM} = MMBS5060 = 30 V MMBS5061 = 60 V MMBS5062 = 100 V	I_{FXM}	—	50	µA
Peak Reverse Blocking Current (R_{GC} = 1.0 kΩ, T_C = 125°C)	V_{RXM} = MMBS5060 = 30 V MMBS5061 = 60 V MMBS5062 = 100 V	I_{RXM}	—	50	µA
Forward Voltage* (I_F = 1.2 A Peak)		V_F	—	1.7	V
Gate Trigger Current** (R_{GC} = 1.0 kΩ, V_{AC} = 7.0 V, R_L = 100 Ω		I_{GT}	—	200	µA
Gate Trigger Voltage (R_{GC} = 1.0 kΩ, V_{AC} = 7.0 V, R_L = 100 Ω		V_{GT}	—	0.8	V
Holding Current (V_{AC} = 7.0 V, R_{GC} = 1.0 kΩ		I_H	—	5.0	mA

*PW ≤ 1.0 ms, D.C. ≤ 1.0%.
**RGC current not included in measurement.

MMBT404,A

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

CHOPPER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value 404	Value 404A	Unit
Collector-Emitter Voltage	V_{CEO}	24	35	Vdc
Collector-Base Voltage	V_{CBO}	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	25	Vdc
Collector Current — Continuous	I_C	150		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	MMBT404 MMBT404A	$V_{(BR)CEO}$	24 35	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	MMBT404 MMBT404A	$V_{(BR)CBO}$	25 40	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	MMBT404 MMBT404A	$V_{(BR)EBO}$	12 25	— —	— —	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)		I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 12$ mAdc, $V_{CE} = 0.15$ Vdc)		h_{FE}	30	—	400	—
Collector-Emitter Saturation Voltage ($I_C = 12$ mAdc, $I_B = 0.4$ mAdc) ($I_C = 24$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	— —	— —	0.15 0.20	Vdc
Base-Emitter Saturation Voltage ($I_C = 12$ mAdc, $I_B = 0.4$ mAdc) ($I_C = 24$ mAdc, $I_B = 1.0$ mAdc)		$V_{BE(sat)}$	— —	— —	0.85 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance ($V_{CB} = 6.0$ Vdc, $I_E = 0$)		C_{obo}	—	—	20	pF
SWITCHING CHARACTERISTICS						
Delay Time ($V_{CC} = 10$ Vdc, $I_C = 10$ mAdc) (Figure 1)		t_d	—	43	—	ns
Rise Time ($I_{B1} = 1.0$ mAdc, $V_{BE(off)} = 14$ Vdc)		t_r	—	180	—	ns
Storage Time ($V_{CC} = 10$ Vdc, $I_C = 10$ mAdc)		t_s	—	675	—	ns
Fall Time ($I_{B1} = I_{B2} = 1.0$ mAdc) (Figure 1)		t_f	—	160	—	ns

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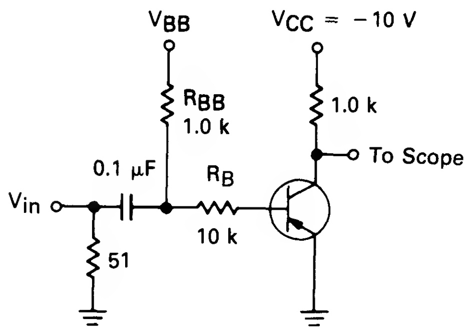
FIGURE 1 — SWITCHING TIME TEST CIRCUIT



	V_{in} (Volts)	V_{BB} (Volts)
t_{on}, t_d, t_r	− 12	+1.4
t_{off}, t_s and t_f	+20.6	−11.6

Voltages and resistor values shown are for I_C = 10 mA, I_C/I_B = 10 and I_{B1} = I_{B2}

MMBT918

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

VHF/UHF TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	350	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

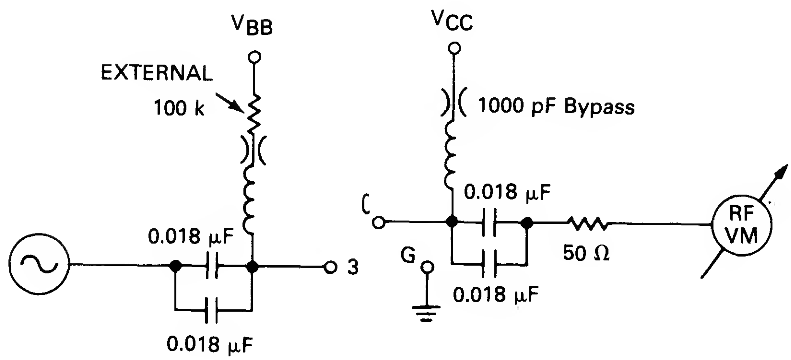
*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	—	MHz
Output Capacitance (V_{CB} = 0 Vdc, I_E = 0, f = 1.0 MHz) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	 — —	 3.0 1.7	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 Ω, f = 60 MHz) (Figure 1)	NF	—	6.0	dB
Power Output (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, f = 500 MHz)	P_{out}	30	—	mW
Common-Emitter Amplifier Power Gain (I_C = 6.0 mAdc, V_{CB} = 12 Vdc, f = 200 MHz)	G_{pe}	11	—	dB

3

FIGURE 1 — NF, Gpe MEASUREMENT CIRCUIT 20-200



NF Test Conditions
I_C = 1.0 Amp
V_{CE} = 6.0 Volts
R_S = 50 Ω
f = 60 MHz

Gpe Test Conditions
I_C = 6.0 mA
V_{CE} = 12 Volts
f = 200 MHz

MMBT930

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)	I_{CEO}	—	10	nAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	I_{CBO}	—	10	nAdc
Collector Cutoff Current (V_{CE} = 45 Vdc, V_{BE} = 0)	I_{CES}	—	10	nAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 500 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 100 150 —	 300 — 600	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)	f_T	30	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 kHz)	NF	—	3.0	dB

3

MMBT2222,A

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

TRANSISTOR

NPN SILICON

Refer to MPS2222 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MMBT2222	MMBT2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	600		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	 MMBT2222 MMBT2222A	$V_{(BR)CEO}$	 30 40	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 MMBT2222 MMBT2222A	$V_{(BR)CBO}$	 60 75	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 MMBT2222 MMBT2222A	$V_{(BR)EBO}$	 5.0 6.0	 — —	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MMBT2222A	I_{CEX}	—	10	nAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C) (V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C)	 MMBT2222 MMBT2222A MMBT2222 MMBT2222A	I_{CBO}	 — — — —	 0.01 0.01 10 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	MMBT2222A	I_{EBO}	—	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MMBT2222A	I_{BL}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	 MMBT2222A only MMBT2222 MMBT2222A	h_{FE}	 35 50 75 35 100 50 30 40	 — — — — 300 — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 MMBT2222 MMBT2222A MMBT2222 MMBT2222A	$V_{CE(sat)}$	 — — — —	 0.4 0.3 1.6 1.0	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MMBT2222		—	1.3	
	MMBT2222A		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	MMBT2222		—	2.6	
	MMBT2222A		—	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMBT2222		250	—	
	MMBT2222A		300	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MMBT2222		—	30	
	MMBT2222A		—	25	
Input Impedance		h_{ie}			kΩ
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		0.25	1.25	
Voltage Feedback Ratio		h_{re}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		25	200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	MMBT2222A	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	MMBT2222A	NF	4.0	4.0	dB

SWITCHING CHARACTERISTICS MMBT2222A only

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

3

MMBT2369

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

Refer to MPS2369 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 125°C$)	I_{CBO}	 — —	 — —	 0.4 30	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 100$ mAdc, $V_{CE} = 2.0$ Vdc)	h_{FE}	 40 20 20	 — — —	 120 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	0.70	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Small Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	h_{fe}	5.0	—	—	—
SWITCHING CHARACTERISTICS					
Storage Time ($I_{B1} = I_{B2} = I_C = 10$ mAdc)	t_s	—	5.0	13	ns
Turn-On Time ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc)	t_{on}	—	8.0	12	ns
Turn-Off Time ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc, $I_{B2} = 1.5$ mAdc)	t_{off}	—	10	18	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBT2484

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

LOW NOISE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to MPSA18 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0) (V_{CB} = 45 Vdc, I_E = 0, T_A 150°C)	I_{CBO}	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 250 —	 — 800	—
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	0.35	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	6.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	3.0	dB

MMBT2907,A

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to MPS2907 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	MPS2907	MPS2907A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 MMBT2907 MMBT2907A	$V_{(BR)CEO}$	 40 60	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc)		I_{CEX}	—	50	nAdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)	 MMBT2907 MMBT2907A	I_{CBO}	 — —	 0.020 0.010	μAdc
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 125°C$)	MMBT2907 MMBT2907A		— —	20 10	
Base Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc)		I_B	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc)	 MMBT2907 MMBT2907A	h_{FE}	 35 75	 — —	—
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	MMBT2907 MMBT2907A		50 100	— —	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	MMBT2907 MMBT2907A		75 100	— —	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1)	MMBT2907, MMBT2907A		100	300	
($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1)	MMBT2907 MMBT2907A		30 50	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	 — —	 0.4 1.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	 — —	 1.3 2.6	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1),(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	—	45	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	100	ns
Storage Time		t_s	—	80	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

3

3

MMBT3640

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

PNP SILICON

Refer to MPS3640 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	80	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0) (V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	— —	0.01 1.0	μAdc
Base Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)	I_B	—	10	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 20	120 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 65°C)	$V_{CE(sat)}$	— — —	0.2 0.6 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	0.75 0.8 —	0.95 1.0 1.5	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 Vdc, I_{B1} = 5.0 mAdc)	t_d	—	10	ns
Rise Time	t_r	—	30	ns
Storage Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	t_s	—	20	ns
Fall Time	t_f	—	12	ns
Turn-On Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 Vdc, I_{B1} = 5.0 mAdc) (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 0.5 mAdc)	t_{on}	— —	25 60	ns
Turn-Off Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 V, I_{B1} = I_{B2} = 5.0 mAdc) (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 0.5 mAdc)	t_{off}	— —	35 75	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBT3903
MMBT3904

CASE 318-03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltge	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to 2N3903 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)		I_{BL}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)		I_{CEX}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	MMBT3903 MMBT3904	h_{FE}	20 40	— —	—
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MMBT3903 MMBT3904		35 70	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MMBT3903 MMBT3904		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	MMBT3903 MMBT3904		30 60	— —	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MMBT3903 MMBT3904		15 30	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	— —	0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	0.65 —	0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMBT3903 MMBT3904	f_T	250 300	— —	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT3903 MMBT3904	h_{ie}	1.0 1.0	8.0 10	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT3903 MMBT3904	h_{re}	0.1 0.5	5.0 8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT3903 MMBT3904	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)	MMBT3903 MMBT3904	NF	— —	6.0 5.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	MMBT3903 MMBT3904	t_s	— —	175 200	ns
Fall Time			t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBT3906

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

Refer to 2N3905 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)	I_{BL}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)	I_{CEX}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 60 80 100 60 30	 — — 300 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.25 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	10.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	2.0	12	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.1	10	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	400	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	3.0	60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k onm, f = 10 10 Hz to 15.7 kHz)		NF	—	4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	75	ns

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

MMBT4124

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N4123 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	2N4124	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_E = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 2.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 120 60	 360 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	8.0	pF
Collector-Base Capacitance (I_E = 0, V_{CB} = 5.0 V, f = 100 kHz)	C_{cb}	—	4.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	120	480	—
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) (I_C = 2.0 mAdc, V_{CE} = 10 V, f = 1.0 kHz)	$\|h_{fe}\|$	 3.0 120	 — 480	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	NF	—	5.0	dB

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

3

MMBT4125

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N4125 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	30	25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_E = 0)	$V_{(BR)CEO}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 2.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	50 25	150 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	10	pF
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	4.5	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	200	—
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	$\|h_{fe}\|$	2.0	—	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	NF	—	5.0	dB

(1) Pulse Test: Pulse Width = 300 μsec, Duty Cycle = 2.0%.

MMBT4401

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to 2N4401 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 35$ Vdc, $V_{EB} = 0.4$ Vdc)	I_{BEV}	—	0.1	μAdc
Collector Cutoff Current ($V_{CE} = 35$ Vdc, $V_{EB} = 0.4$ Vdc)	I_{CEX}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)	h_{FE}	20 40 80 100 40	— — — 300 —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{CE(sat)}$	— —	0.4 0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{BE(sat)}$	0.75 —	0.95 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	250	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)	C_{cb}	—	6.5	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{eb}	—	30	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ie}	1.0	15	k ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{re}	0.1	8.0	$X\ 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	40	500	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{oe}	1.0	30	μmhos

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	($V_{CC} = 30$ Vdc, $V_{EB} = 2.0$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

MMBT4403

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 35 Vdc, V_{BE} = 0.4 Vdc)	I_{BEV}	—	0.1	μAdc
Collector Cutoff Current (V_{CE} = 35 Vdc, V_{BE} = 0.4 Vdc)	I_{CEX}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 2.0 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)(1)	h_{FE}	30 60 100 100 20	— — — 300 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	— —	0.4 0.75	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.75 —	0.95 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{cb}	—	8.5	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{eb}	—	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.5k	15k	ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.1	8.0	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	60	500	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	1.0	100	μmhos
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 30 Vdc, V_{BE} = 2.0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	ns
Rise Time	t_r	—	20	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time	t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBT5086,87

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

LOW NOISE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	50	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 35 Vdc, I_E = 0)		I_{CBO}	 — —	 10 50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	 MMBT5086 MMBT5087	h_{FE}	 150 250	 500 800	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT5086 MMBT5087		150 250	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT5086 MMBT5087		150 250	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	40	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	 MMBT5086 MMBT5087	h_{fe}	 150 250	 600 900	—
Noise Figure (I_C = 20 mAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 kHz)	 MMBT5086 MMBT5087	NF	 — —	 3.0 2.0	dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 3.0 kΩ, f = 1.0 kHz)	MMBT5086 MMBT5087		— —	3.0 2.0	

3

MMBT5088,89

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

LOW NOISE TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value MMBT5088	Value MMBT5089	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	35	30	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	50		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MMBT5088 MMBT5089	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MMBT5088 MMBT5089	$V_{(BR)CBO}$	35 30	— —	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0)	MMBT5088 MMBT5089	I_{CBO}	— —	50 50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0) ($V_{EB(off)}$ = 4.5 Vdc, I_C = 0)	MMBT5088 MMBT5089	I_{EBO}	— —	50 100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089	h_{FE}	300 400	900 1200	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089		350 450	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089		300 400	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.8	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz emitter guarded)		C_{cb}	—	4.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz collector guarded)		C_{eb}	—	10	pF
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	MMBT5088 MMBT5089	h_{fe}	350 450	1400 1800	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 Hz)	MMBT5088 MMBT5089	NF	— —	3.0 2.0	dB

MMBT5401

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to 2N5401 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	150	Vdc
Collector-Base Voltage	V_{CBO}	160	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	150	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	160	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 50 50	 nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 50 60 50	 — 240 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.20 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 — —	 1.0 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	300	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	40	200	—
Noise Figure (I_C = 200 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 ohms, f = 10 Hz to 15.7 kHz)	NF	—	8.0	dB

MMBT5550

CASE 318-02/03, STYLE 6 SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to 2N5550 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	140	Vdc
Collector-Base Voltage	V_{CBO}	160	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	140	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_C = 0)	$V_{(BR)CBO}$	160	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 100 100	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 60 60 20	 — 250 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.15 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 — —	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	300	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	30	pF

MMBT6427

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_C = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)	I_{CEO}	—	1.0	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 10,000 20,000 14,000	 100,000 200,000 140,000	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 0.5 mAdc) (I_C = 500 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	 — —	 1.2 1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	—	2.0	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	—	1.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	7.0	pF
Input Capacitance (V_{BE} = 0.5, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	15	pF
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	$\|h_{fe}\|$	1.3	—	Vdc
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 kΩ, f = 1.0 kHz to 15.7 kHz)	NF	—	10	dB

3

MMBT6428,29

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value MMBT6428	Value MMBT6429	Unit
Collector-Emitter Voltage	V_{CEO}	50	45	Vdc
Collector-Base Voltage	V_{CBO}	60	55	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MMBT6428 MMBT6429	$V_{(BR)CEO}$	 50 45	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$) ($I_C = 0.1$ mAdc, $I_E = 0$)	 MMBT6428 MMBT6429	$V_{(BR)CBO}$	 60 55	 — —	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.01$ mAdc, $V_{CE} = 5.0$ Vdc)	 MMBT6428 MMBT6429	h_{FE}	 250 500	 — —	—
($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	MMBT6428 MMBT6429		250 500	650 1250	
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	MMBT6428 MMBT6429		250 500	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	MMBT6428 MMBT6429		250 500	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc) ($I_C = 100$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.6	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	0.56	0.66	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	100	700	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	3.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	8.0	pF

MMBT6517

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	350	Vdc
Collector-Base Voltage	V_{CBO}	350	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Base Current	I_B	250	mA
Collector Current — Continuous	I_C	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to 2N6517 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mA)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 250 V)	I_{CBO}	—	50	nA
Emitter Cutoff Current (V_{EB} = 5.0 V)	I_{EBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V) (I_C = 30 mA, V_{CE} = 10 V) (I_C = 50 mA, V_{CE} = 10 V) (I_C = 100 mA, V_{CE} = 10 V)	h_{FE}	 20 30 30 20 15	 — — 200 100 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA) (I_C = 20 mA, I_B = 2.0 mA) (I_C = 30 mA, I_B = 3.0 mA) (I_C = 50 mA, I_B = 5.0 mA)	$V_{CE(sat)}$	 — — — —	 0.30 0.35 0.50 1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA) (I_C = 20 mA, I_B = 2.0 mA) (I_C = 30 mA, I_B = 3.0 mA)	$V_{BE(sat)}$	 — — —	 0.75 0.85 0.90	Vdc
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 10 V)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mA, V_{CE} = 20 V, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = 20 V, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 V, f = 1.0 MHz)	C_{eb}	—	80	pF

MMBT6520

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to 2N6520 for graphs.

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	350	Vdc
Collector-Base Voltage	V_{CBO}	350	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Base Current	I_B	250	mA
Collector Current — Continuous	I_C	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mA)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 250 V)	I_{CBO}	—	50	nA
Emitter Cutoff Current (V_{EB} = 4.0 V)	I_{EBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V) (I_C = 30 mA, V_{CE} = 10 V) (I_C = 50 mA, V_{CE} = 10 V) (I_C = 100 mA, V_{CE} = 10 V)	h_{FE}	 20 30 30 20 15	 — — 200 100 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA) (I_C = 20 mA, I_B = 2.0 mA) (I_C = 30 mA, I_B = 3.0 mA) (I_C = 50 mA, I_B = 5.0 mA)	$V_{CE(sat)}$	 — — — —	 0.30 0.35 0.50 1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA) (I_C = 20 mA, I_B = 2.0 mA) (I_C = 30 mA, I_B = 3.0 mA)	$V_{BE(sat)}$	 — — —	 0.75 0.85 0.90	Vdc
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 10 V)	$V_{BE(on)}$			Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mA, V_{CE} = 20 V, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = 20 V, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 V, f = 1.0 MHz)	C_{eb}	—	100	pF

MMBT6543

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AMPLIFIER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	60	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	200	350	mVdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	750	950	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	750	1100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	0.8	1.0	pF
Collector Base Time Constant (I_E = 4.0 mAdc, V_{CE} = 12 Vdc, f = 31.8 MHz)	$r_{b'}C_c$	—	—	9.5	ps

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

MMBTA05,06

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DRIVER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value MMBTA05	Value MMBTA06	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MMBTA05 MMBTA06	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MMBTA05 MMBTA06	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 50 50	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 10 mA, V_{CE} = 2.0 V, f = 100 MHz)		f_T	100	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MMBTA13,14

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DARLINGTON AMPLIFIER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	300	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to 2N6426 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_B = 0$)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	MMBTA13 MMBTA14 MMBTA13 MMBTA14	h_{FE}	5000 10,000 10,000 20,000	— — — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		V_{BE}	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

3

MMBTA20

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE AMPLIFIER

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.0	pF

MMBTA42,43

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MMBTA42	MMBTA43	
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to MPSA42 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	MMBTA42 MMBTA43	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MMBTA42 MMBTA43	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	MMBTA42 MMBTA43	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0) (V_{BE} = 4.0 Vdc, I_C = 0)	MMBTA42 MMBTA43	I_{EBO}	— —	0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	Both Types Both Types MMBTA42 MMBTA43	h_{FE}	25 40 40 40	— — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	MMBTA42 MMBTA43	$V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MMBTA42 MMBTA43	C_{cb}	— —	3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBTA55,56

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DRIVER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MMBTA55	MMBTA56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MMBTA55 MMBTA56	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MMBTA55 MMBTA56	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 50 50	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc, f = 100 MHz)		f_T	50	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MMBTA63
MMBTA64

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DARLINGTON TRANSISTOR

PNP SILICON

Refer to MPSA75 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1000 mAdc, V_{CE} = 5.0 Vdc)	 MMBTA63 MMBTA64 MMBTA63 MMBTA64	h_{FE}	 5,000 10,000 10,000 20,000	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 50 Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

MMBTA70

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.0	pF

MMBTA92,93

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

3

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MMBTA92	MMBTA93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	5.0	Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	MMBTA92 MMBTA93	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MMBTA92 MMBTA93	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	MMBTA92 MMBTA93	I_{CBO}	— —	0.25 0.25	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	Both Types Both Types MMBTA92 MMBTA93	h_{FE}	25 40 25 25	— — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	MMBTA92 MMBTA93	$V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MMBTA92 MMBTA93	C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

MMBTH10

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

VHF/UHF TRANSISTOR

NPN SILICON

Refer to MPSH10 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	—	—
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	V_{BE}	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	650	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.7	pF
Common-Base Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{rb}	0.35	0.65	pF
Collector Base Time Constant (I_C = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	—	9.0	ps

MMBTH24

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

VHF MIXER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	620	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.25	0.36	pF
Conversion Gain	—				dB
(213 MHz to 45 MHz) (I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)	C_G	19	24	—	
(60 MHz to 45 MHz) (I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)		24	29	—	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBTH81

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

UHF/VHF TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	—	—	—
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	—	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	0.85	pF
Collector-Emitter Capacitance (I_B = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{ce}	—	—	0.65	pF

MMBV105G

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

VOLTAGE VARIABLE CAPACITANCE DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 28 Vdc)	I_R	—	—	50	nAdc
Series Inductance (f = 250 MHz)	L_S	—	3.0	—	nH
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	T_{CC}	—	280	—	ppm/°C
Diode Capacitance (V_R = 25 Vdc)	C_T	1.8	—	2.8	pF
Capacitance (V_{R1} = 3.0 Vdc, V_{R2} = 25 Vdc, f = 1.0 MHz)	C3/C25	4.0	—	6.0	pF

MMBV109

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

VOLTAGE VARIABLE CAPACITANCE DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 28 Vdc)	I_R	—	—	0.1	μAdc
Series Inductance (f = 250 MHz)	L_S	—	3.0	—	nH
Case Capacitance (f = 1.0 MHz)	C_C	—	0.1	—	pF
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	—	280	—	ppm/°C
Figure of Merit (V_R = 3.0 Vdc, f = 50 MHz)	Q	280	—	—	—
Diode Capacitance (V_R = 3.0 Vdc, f = 1.0 MHz)	C_T	26	—	32	pF

MMBV2097 thru MMBV2109

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

TUNING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	20	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc)	I_R	—	—	20	nAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16″)	L_S	—	3.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16″)	C_C	—	0.15	—	pF
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	—	280	400	ppm/°C

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc f = 50 MHz	TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Marking
	Min	Nom	Max	Min	Min	Max	Top
MMBV-2101	6.1	6.8	7.5	450	2.5	3.3	4G
MMBV-2102	7.3	8.2	9.0	275	2.6	3.3	4S
MMBV-2103	9.0	10	11	400	2.6	3.3	4H
MMBV2104	10.8	12	13.2	275	2.6	3.3	4T
MMBV-2105	13.5	15	16.5	275	2.6	3.3	4U
MMBV-2106	16.2	18	19.8	250	2.7	3.3	4V
MMBV-2107	19.8	22	24.2	200	2.7	3.3	4W
MMBV-2108	24.3	27	29.7	300	2.7	3.3	4X
MMBV-2109	29.7	33	36.3	200	2.7	3.3	4J

MMBV3102

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

VOLTAGE VARIABLE CAPACITANCE DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc)	I_R	—	—	0.1	μAdc
Series Inductance (f = 250 MHz)	L_S	—	3.0	—	nH
Case Capacitance (f = 1.0 MHz)	C_C	—	0.1	—	pF
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	T_{CC}	—	280	—	ppm/°C
Figure of Merit (V_R = 3.0 Vdc, f = 50 MHz)	Q	300	—	—	—
Diode Capacitance (V_R = 3.0 Vdc, f = 1.0 MHz)	C_T	20	—	25	pF

MMBV3401

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

SILICON PIN
SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)}$	35	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc)	I_R	—	—	0.1	μAdc
Series Inductance (f = 250 MHz)	L_S	—	3.0	—	nH
Series Resistance (I_F = 10 mAdc)	R_S	—	—	0.7	Ohms
Case Capacitance (f = 1.0 MHz)	C_C	—	0.1	—	pF
Diode Capacitance (V_R = 20 Vdc, f = 1.0 MHz)	C_T	—	—	1.0	pF

3

MXR3866

CASE 345-01, STYLE 1
SOT-89

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Base Voltage	V_{CBO}	55	V
Emitter-Base Voltage	V_{EBO}	3.5	V
Collector Current — Continuous	I_C	0.4	A
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 5.0 mA, R_{BE} = 10 Ω)	$V_{(BR)CER}$	55	—	V
Collector-Emitter Sustaining Voltage (I_C = 5.0 mA)	$V_{CEO(sus)}$	30	—	V
Collector-Base Breakdown Voltage (I_C = 0.1 mA)	$V_{(BR)CBO}$	55	—	V
Emitter-Base Breakdown Voltage (I_E = 0.1 mA)	$V_{(BR)EBO}$	3.5	—	V
Collector Cutoff Current (V_{CE} = 28 V)	I_{CEO}	—	20	μA
Collector Cutoff Current (V_{CE} = 55 V, V_{BE} = 1.5 V)	I_{CEX}	—	100	μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.36 A, V_{CE} = 5.0 V) (I_C = 0.05 A, V_{CE} = 5.0 V)	h_{FE}	 5.0 10	 — 200	—
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 20 mA)	$V_{CE(sat)}$	—	1.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mA, V_{CE} = 15 V, f = 200 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = 30 V, f = 1.0 MHz)	C_{obo}	—	3.0	pF

MXR5160

CASE 345-01, STYLE 1
SOT-89

RF TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	V
Collector-Base Voltage	V_{CBO}	60	V
Emitter-Base Voltage	V_{EBO}	4.0	V
Collector Current — Continuous	I_C	0.4	A
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 5.0 mA)	$V_{CEO(sus)}$	40	—	V
Emitter-Base Breakdown Voltage (I_E = 0.1 mA)	$V_{(BR)EBO}$	4.0	—	V
Collector Cutoff Current (V_{CB} = 28 V)	I_{CBO}	—	1.0	μA
Collector Cutoff Current (V_{CE} = 60 V)	I_{CES}	—	0.1	mA
Emitter Cutoff Current (V_{CE} = 28 V)	I_{CEO}	—	20	μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mA, V_{CE} = 5.0 V)	h_{FE}	10	—	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mA, V_{CE} = 15 V, f = 200 MHz)	f_T	500	—	MHz

3

MXR5583

CASE 345-01, STYLE 1
SOT-89

HIGH FREQUENCY RF TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Base Voltage	V_{CBO}	30	V
Emitter-Base Voltage	V_{EBO}	3.0	V
Collector Current — Continuous	I_C	500	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mA)	$V_{(BR)CEO}$	30	—	V
Collector-Base Breakdown Voltage(1) ($I_C = 10\ \mu A$)	$V_{(BR)CBO}$	30	—	V
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu A$)	$V_{(BR)EBO}$	3.0	—	V
Collector Cutoff Current ($V_{CB} = 20$ V)	I_{CBO}	—	50	nA
Emitter Cutoff Current ($V_{EB} = 2.0$ V)	I_{EBO}	—	0.5	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 40$ mA, $V_{CE} = 2.0$ V) ($I_C = 100$ mA, $V_{CE} = 2.0$ V) ($I_C = 300$ mA, $V_{CE} = 5.0$ V)	h_{FE}	 20 25 15	 — 100 —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mA, $I_B = 10$ mA)	$V_{CE(sat)}$	—	0.8	V
Base-Emitter On Voltage ($I_C = 100$ mA, $V_{CE} = 2.0$ V)	$V_{BE(on)}$	—	1.8	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 40$ mA, $V_{CE} = 10$ V, f = 100 MHz) ($I_C = 100$ mA, $V_{CE} = 10$ V, f = 100 MHz)	f_T	 1000 1300	 — —	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MXR5943

CASE 345-01, STYLE 1
SOT-89

RF TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Base Voltage	V_{CBO}	40	V
Emitter-Base Voltage	V_{EBO}	3.5	V
Collector Current — Continuous	I_C	400	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 5.0 mA)	$V_{(BR)CEO}$	30	—	V
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	40	—	V
Emitter-Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	3.5	—	V
Collector Cutoff Current (V_{CE} = 20 V)	I_{CEO}	—	50	μA
Collector Cutoff Current (V_{CB} = 15 V)	I_{CBO}	—	10	μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mA, V_{CE} = 15 V)	h_{FE}	25	300	—
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)	$V_{CE(sat)}$	—	0.2	V
Base-Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)	$V_{BE(sat)}$	—	1.0	V
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 25 mA, V_{CE} = 15 V, f = 200 MHz) (I_C = 50 mA, V_{CE} = 15 V, f = 200 MHz) (I_C = 100 mA, V_{CE} = 15 V, f = 200 MHz)	f_T	 1000 1200 1000	 — — —	MHz

3

MXT3904

CASE 345-01, STYLE 1
SOT-89

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltge	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

Refer to 2N3904 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)	I_{BL}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 3.0 Vdc)	I_{CEX}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 40 70 100 60 30	 — — 300 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.0	10	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.5	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	400	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)		NF	—	5.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_s	—	200	ns
Fall Time		t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

3

MXT3906

CASE 345-01, STYLE 1
SOT-89

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

Refer to 2N3905 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)	I_{BL}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)	I_{CEX}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 60 80 100 60 30	 — — 300 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.25 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	10.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	2.0	12	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.1	10	$X\ 10^{-4}$
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	400	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	3.0	60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)		NF	—	4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	75	ns

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

3

MXTA14

CASE 345-01, STYLE 1
SOT-89

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Emitter Voltage	V_{CES}	30	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current — Continuous	I_C	300	mV

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CES}$	30	—	V
Collector Cutoff Current (V_{CB} = 30)	I_{CBO}	—	100	nA
Emitter Cutoff Current (V_{BE} = 10 V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mA, V_{CE} = 5.0 V) (I_C = 100 mA, V_{CE} = 5.0 V)	h_{FE}	 10 K 20 K	 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 100 mA, I_B = 0.1 mA)	$V_{CE(sat)}$	—	1.5	V
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 5.0 V)	$V_{BE(on)}$	—	2.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 5.0 V, I_C = 10 mA, f = 100 MHz)	f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0 %.

MXTA27

CASE 345-01, STYLE 1
SOT-89

DARLINGTON TRANSISTOR

NPN SILICON

Refer to MPSA25 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	60	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current — Continuous	I_C	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CES}$	60	—	V
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	60	—	V
Collector Cutoff Current (V_{CB} = 50 V)	I_{CBO}	—	100	nA
Collector Cutoff Current (V_{CE} = 50 V)	I_{CES}	—	500	nA
Emitter Cutoff Current (V_{BE} = 10 V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mA, I_B = 0.1 A)	V_{CES}	—	1.5	V
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 5.0 V)	$V_{BE(on)}$	—	2.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain (I_C = 10 mA, V_{CE} = 5.0 V) (I_C = 100 mA, V_{CE} = 5.0 V)	h_{FE}	 10 K 10 K	 — —	—
Current Gain — High Frequency (I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)	$\|h_{fe}\|$	1.25	—	—

3

MXTA42
MXTA43

CASE 345-01, STYLE 1
SOT-89

HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPSA42	MPSA43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MXTA42 MXTA43	$V_{(BR)CEO}$	 300 200	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MXTA42 MXTA43	$V_{(BR)CBO}$	 300 200	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	 MXTA42 MXTA43	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0) (V_{BE} = 4.0 Vdc, I_C = 0)	 MXTA42 MXTA43	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	 Both Types Both Types MXTA42 MXTA43	h_{FE}	 25 40 40 40	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	 MXTA42 MXTA43	$V_{CE(sat)}$	 — —	 0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	 MXTA42 MXTA43	C_{cb}	 — —	 3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MXTA44

CASE 345-01, STYLE 1
SOT-89

HIGH VOLTAGE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	400	V
Collector-Base Voltage	V_{CBO}	500	V
Emitter-Base Voltage	V_{EBO}	6.0	V
Collector Current — Continuous	I_C	300	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

Refer to MPSA44 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mA, $I_B = 0$)	$V_{(BR)CEO}$	400	—	V
Collector-Emitter Breakdown Voltage ($I_C = 100$ μA, $V_{BE} = 0$)	$V_{(BR)CES}$	500	—	V
Collector-Base Breakdown Voltage ($I_C = 100$ μA, $I_B = 0$)	$V_{(BR)CBO}$	500	—	V
Emitter-Base Breakdown Voltage ($I_E = 10$ μA, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	V
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 1.0$ mA, $V_{CE} = 10$) ($I_C = 10$ mA, $V_{CE} = 10$) ($I_C = 50$ mA, $V_{CE} = 10$) ($I_C = 100$ mA, $V_{CE} = 10$)	h_{FE}	 40 50 45 40	 — 200 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 1.0$ mA, $I_B = 0.1$ mA) ($I_C = 10$ mA, $I_B = 1.0$ mA) ($I_C = 50$ mA, $I_B = 5.0$ mA)	$V_{CE(sat)}$	 — — —	 0.4 0.5 0.75	V
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{BE(sat)}$	—	0.75	V
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 20$ V, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5$ V, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	110	pF
Current Gain — High Frequency ($I_C = 10$ mA, $V_{CE} = 10$ V, f = 10 MHz)	$\|h_{fe}\|$	2.0	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0 %.

MXTA64

CASE 345-01, STYLE 1
SOT-89

DARLINGTON TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	300	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc)	I_{CBO}	—	100	nA
Emitter Cutoff Current ($V_{BE} = 10$ Vdc)	I_{EBO}	—	100	nAc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mA, $V_{CE} = 5.0$ Vdc)(1) ($I_C = 100$ mA, $V_{CE} = 5.0$ Vdc)(1)	h_{FE}	 10000 20000	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mA, $I_B = 0.1$ mA)(1)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mA, $V_{CE} = 5.0$ Vdc)(1)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($V_{CE} = 5.0$ Vdc, $I_C = 100$ mA, f = 100 MHz)	f_T	125	—	MHz

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MXTA77

CASE 345-01, STYLE 1
SOT-89

DARLINGTON TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	60	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current — Continuous	I_C	300	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

Refer to MPSA75 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CES}$	60	—	V
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	60	—	V
Collector Cutoff Current (V_{CB} = 50 V)	I_{CBO}	—	100	nA
Collector Cutoff Current (V_{CE} = 50 V)	I_{CES}	—	500	nA
Emitter Cutoff Current (V_{BE} = 10 V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mA, V_{CE} = 5.0 V) (I_C = 100 mA, V_{CE} = 5.0 V)	h_{FE}	 10 K 10 K	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 0.1 mA)	$V_{CE(sat)}$	—	1.5	V
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 5.0 V)	$V_{BE(on)}$	—	2.0	V
Current Gain — High Frequency (I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)	$\|h_{fe}\|$	1.25	—	—

3

MXTA92
MXTA93

CASE 345-01, STYLE 1
SOT-89

HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS-A92	MPS-A93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

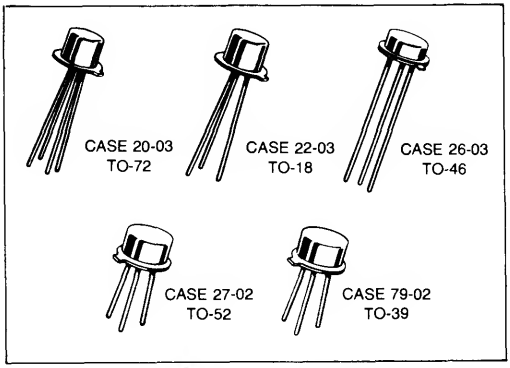
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	MXTA92 MXTA93	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	MXTA92 MXTA93	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	MXTA92 MXTA93	I_{CBO}	— —	0.25 0.25	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	Both Types Both Types MXTA92 MXTA93	h_{FE}	25 40 25 25	— — — 150	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	MXTA92 MXTA93	$V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	MXTA92 MXTA93	C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



Motorola's metal-can transistor product offering includes: general purpose, switching, high voltage, choppers, Darlingtons, low noise amplifiers and RF amplifiers.

A variety of package options are available: TO-18, TO-46, TO-52, TO-72, and TO-39.

Many devices contained in this section are also available with high reliability MIL-S-19500 processing. JAN, JANTX, JANTXV, and JANS qualified devices are so noted on the following data sheets.

Metal Transistors

4

4

2N697

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N2218 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.0 13.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 100$ mAdc, $R_{BE} = 10$ ohms)	$V_{(BR)CER}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 1.0 100	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	120	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$)	C_{obo}	—	35	pF
Small-Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	h_{fe}	2.5	—	MHz

(1) Pulse Test: Pulse Length ≤ 12 ms, Duty Cycle ≤ 2.0%.

2N699

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.0 13.3	Watts mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	75	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	250	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 100 mAdc, $R_{BE} \leqq$ 10 ohms)	$V_{(BR)CER}$	80	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 2.0 200	μAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	120	—
Collector-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	20	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ib}	 20 —	 30 10	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 khZ)	h_{rb}	 — —	 2.5 3.0	$X\ 10^{-4}$
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	 35 45	 100 —	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ob}	 0.05 —	 0.5 1.0	μmhos

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N706,A,B

(2N706 JAN AVAILABLE)
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

4

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector-Emitter Voltage	2N706A,B	V_{CEO}	15	Vdc
Collector-Emitter Voltage(1)		V_{CER}	20	Volts
Collector-Base Voltage		V_{CBO}	25	Volts
Emitter-Base Voltage	2N706 2N706A 2N706B	V_{EBO}	3.0 5.0 5.0	Volts
Collector Current	2N706,A,B	I_C	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C		P_D	0.3 2.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C		P_D	1.0 6.67	Watts mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C		P_D	0.5	Watt
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	150	°C/W
Thermal Resistance, Junction to Ambient 2N706A,B	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

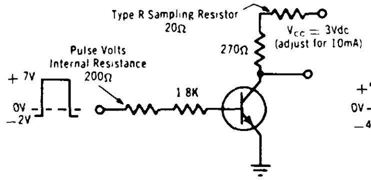
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	Vdc
Collector-Emitter Breakdown Voltage(2) (R = 10 ohms, I_C = 10 mAdc)		$V_{(BR)CER}$	20	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C) (V_{CB} = 25 Vdc, I_E = 0)	 2N706A, 2N706B	I_{CBO}	 — — —	 0.5 30 10	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, R_{BE} = 100k)	 2N706A, 2N706B	I_{CER}	—	10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0) (V_{EB} = 5.0 Vdc, I_C = 0)	 2N706 2N706A, 2N706B	I_{EBO}	 — —	 10 10	μAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	 2N706 2N706A, 2N706B	h_{FE}	 20 20	 — 60	—
Collector-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1.0 mAdc)	 2N706, 2N706A 2N706B	$V_{CE(sat)}$	 — —	 0.6 0.4	Vdc
Base-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1.0 mAdc)	 2N706 2N706A, 2N706B	$V_{BE(sat)}$	 — 0.7	 0.9 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0)	 2N706A, 2N706B 2N706	C_{obo}	 — —	 5.0 6.0	pF
Magnitude of Forward Current Transfer Ratio, Common-Emitter (V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 100 Mhz) (V_{CE} = 10 Vdc, I_E = 10 mAdc, f = 100 MHz)	 2N706 2N706A,B	$\|h_{fe}\|$	 2.0 2.0	 — —	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

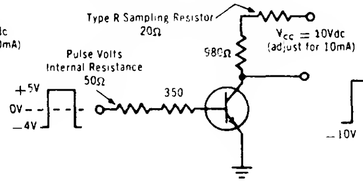
Characteristic		Symbol	Min	Max	Unit
Collector Base Time Constant (V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 300 MHz)		r_b	—	50	ohms
Storage Time	2N706B	t_s	—	25	ns
Turn-On Time (I_{B1} = 3.0 mA, I_{B2} = 1.0 mA)		t_{on}	—	40	ns
Turn-Off Time (I_{B1} = 3.0 mA, I_{B2} = 1.0 mA)		t_{off}	—	75	ns
Charge Storage Time Constant(2)	2N706	τ_s	—	60	ns
	2N706A,B		—	25	

(1) Refers to collector breakdown voltage in the high current region when R_{be} = 10 Ω
(2) Pulse Test: Pulse Width ≤ 12 μs, Duty Cycle ≤ 2.0%.
(3) Switching Times Measured with Tektronix Type R Plug-In (50 Ω Internal Impedance).

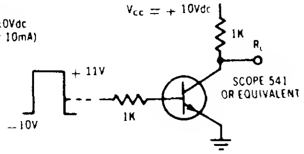
SWITCHING TIME TEST CIRCUIT



STORAGE TIME TEST CIRCUIT



MEASUREMENT CIRCUIT



4

2N708

JAN, JTX AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	limited by P_D only	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	360 2.1	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ $T_C = 100°C$ Derate above 25°C Derate above 100°C	P_D	1.2 680 6.9 6.9	Watts mW mW/°C mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	145	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 30$ mAdc, $R_{BE} \leq 10$ ohms)	$V_{CER(sus)}$	20	—	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 30$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0.25$ Vdc, $T_A = +125°C$)	I_{CEX}	—	10	μAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_C = 0$, $T_A = 150°C$)	I_{CBO}	— —	0.025 15	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.08	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.5$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)(1) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)(1)	h_{FE}	 15 30 15	 — 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 7.0$ mAdc, $I_B = 0.7$ mAdc, $T_A = -55°C$ to $+125°C$)	$V_{CE(sat)}$	 — —	 0.4 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 7.0$ mAdc, $I_B = 0.7$ mAdc, $T_A = -55°C$)	$V_{BE(sat)}$	 0.72 —	 0.80 0.90	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, 100 kHz ≤ f ≤ 1.0 MHz)	C_{obo}	—	6.0	pF
Extrinsic Base Resistance ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 300 MHz)	r_b'	—	50	ohms
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = I_{B1} = I_{B2} = 10$ mAdc)	t_s	—	25	ns
Turn-On Time	t_{on}	—	40	ns
Turn-Off Time	t_{off}	—	70	ns

2N718A
2N956, 2N1711

2N718A JAN, JTX, JTXV AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

2N718A: See 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N718A 2N956	2N1711	Unit
Collector-Emitter Voltage	V_{CER}	50		Vdc
Collector-Base Voltage	V_{CBO}	75		Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 2.86	800 4.57	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3	3.0 17.15	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, pulsed; $R_{BE} \leq 10$ ohms)		$V_{CER(sus)}$	50	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)		I_{CBO}	 — —	 0.001 —	 0.01 10	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	2N718A, 2N956, 2N1711	I_{EBO}	— —	— —	0.010 0.005	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 0.01$ mAdc, $V_{CE} = 10$ Vdc)	2N956, 2N1711	h_{FE}	20	—	—	—
($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc)	2N718A, 2N956, 2N1711		20 35	— —	— —	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	2N718A, 2N956, 2N1711		35 75	— —	— —	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$)	2N718A, 2N956, 2N1711		20 35	— —	— —	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	2N718A, 2N956, 2N1711		40 100	— —	120 300	
($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	2N718A, 2N956, 2N1711		20 40	— —	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{CE(sat)}$	—	0.24	1.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{BE(sat)}$	—	1.0	1.3	Vdc

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.

4

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N718A, 2N956, 2N1711	f_T	60 70	300 300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	20	80	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		h_{ib}	24 4.0	— —	34 8.0	ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N718A, 2N956, 2N1711 2N718A, 2N956, 2N1711	h_{rb}	— — — —	— — — —	3.0 5.0 3.0 5.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A, 2N956, 2N1711 2N718A, 2N956, 2N1711	h_{fe}	30 50 35 70	— — — —	100 200 150 300	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		h_{ob}	0.05 0.05	— —	0.5 0.5	μmhos
Noise Figure (I_C = 300 μAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A, 2N956, 2N1711	NF	— —	— —	12 8.0	dB

2N720A

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, R_{BE} ≤ 10 ohms)	$V_{CER(sus)}$	100	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	.010 15	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	.010	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	h_{FE}	20 35 20 40	— — — 120	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	— —	1.2 5.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	— —	0.9 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{rb}	— —	1.25 1.50	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30 45	100 —	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ob}	— —	0.5 0.5	μmhos

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N869A
2N4453

JAN, JTX, JTXV AVAILABLE

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

2N4453
CASE 26-03, STYLE 1
TO-46 (TO-206AB)

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N869A	2N4453	Unit
Collector-Emitter Voltage	V_{CEO}	18	18	Vdc
Collector-Emitter Voltage	V_{CES}	25		Vdc
Collector-Base Voltage	V_{CBO}	25*	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	400 2.29	mW mW/°C
Total Device Dissipation @ T_C = 25°C TC = 100°C Derate above 25°C	P_D	1.2 0.686 6.86	2.0 1.03 11.3	Watts Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N869A	2N4453	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	97.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	585	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	2N4453	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	2N869A, 2N4453	$V_{(BR)CES}$	25	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{CEO(sus)}$	18	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N869A, 2N4453	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	2N869A	I_{CBO}	—	25	μAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	—	10	nAdc
Emitter Cutoff Current (V_{EB} = 4.5 Vdc, I_C = 0)	2N4453	I_{EBO}	—	10	nAdc
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)	2N869A	I_B	—	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 30 mAdc, V_{CE} = 0.5 Vdc) (I_C = 30 mAdc, V_{CE} = 0.5 Vdc, T_A = −55°C) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	 2N869A 2N869A 2N869A, 2N4453 2N869A, 2N4453 2N869A, 2N4453	h_{FE}	 30 40 40 17 25	 — 120 120 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 1.5 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	 2N869A 2N4453 2N869A 2N869A, 2N4453	$V_{CE(sat)}$	 — — — —	 0.15 0.25 0.2 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 1.5 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	 2N869A 2N4453 2N869A 2N869A, 2N4453	$V_{BE(sat)}$	 0.78 0.8 0.85 —	 0.98 1.1 1.2 1.7	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1)(2) (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)		f_T	400	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	2N869A	C_{obo}	—	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 150 kHz)	2N869A	C_{ibo}	—	6.0	pF
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	2N4453	C_{cb}	—	6.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N4453	C_{eb}	—	6.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	I_C = 30 mAdc, I_{B1} = 1.5 mAdc; V_{CC} = 2.0 Vdc, 2N869A; V_{CC} = 3.0 Vdc 2N4453	t_{on}	—	50	ns
Delay Time	I_C = 30 mAdc, I_{B1} = 1.5 mAdc; V_{CC} = 3.0 Vdc 2N4453	t_d	—	35	ns
Rise Time	I_C = 30 mAdc, I_{B1} = 1.5 mAdc; V_{CC} = 3.0 Vdc 2N4453	t_r	—	20	ns
Turn-Off Time	I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc; V_{CC} = 2.0 Vdc 2N869A; V_{CC} = 3.0 Vdc 2N4453	t_{off}	—	80	ns
Storage Time	I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc; V_{CC} = 3.0 Vdc 2N4453	t_s	—	65	ns
Fall Time	I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc; V_{CC} = 3.0 Vdc 2N4453	t_f	—	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 1.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 — SWITCHING TEST CIRCUIT VALUES

		V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R_L Ohms	I_C mA	I_{B1}(4) mA	I_{B2}(4) mA
t_{on}, t_r, t_d	2N869A	-7.0	3.0	2.0	62	30	1.5	–
	2N4453	-7.0	3.0	3.0	91	30	1.5	–
t_{off}, t_s, t_f	2N869A	+6.0	-4.0	2.0	62	30	1.5	1.5
	2N4453	+6.0	-4.0	3.0	91	30	1.5	1.5

(3) I_C/I_B = 10. Switching is shown to reflect current industry practices. Compare the values shown in Figures 1 and 2 @ I_C = 30 mA to the typical values in the Electrical Characteristics table @ I_C/I_B = 20.

(4) I_{B1} = I_{B2} = 3.0 mA @ I_C/I_B = 10

FIGURE 2 — DC CURRENT GAIN

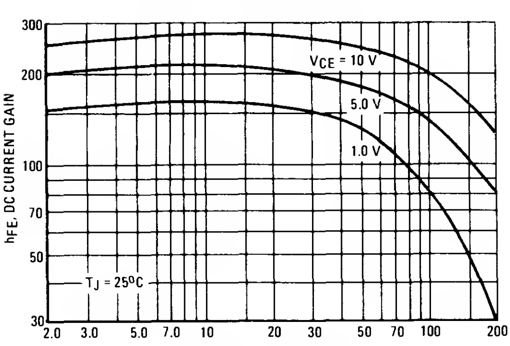
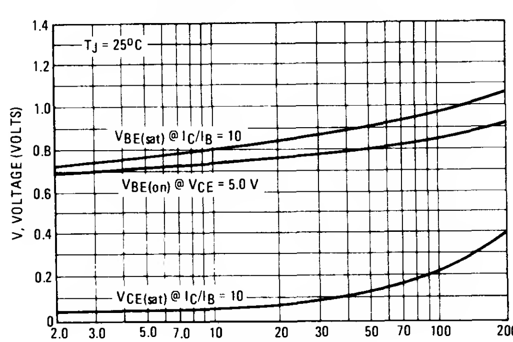


FIGURE 3 — "ON" VOLTAGES



4

FIGURE 4 — CURRENT-GAIN — BANDWIDTH PRODUCT

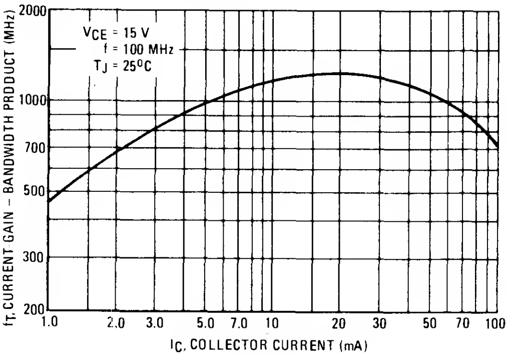


FIGURE 5 — TURN-ON TIME

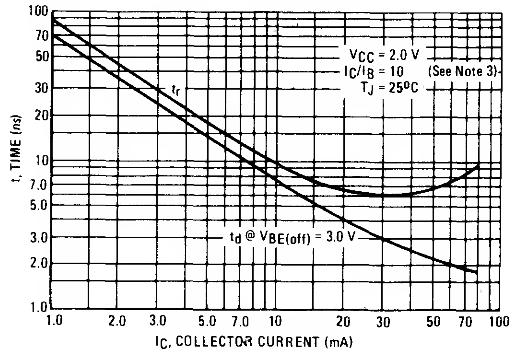


FIGURE 6 — TURN-OFF TIME

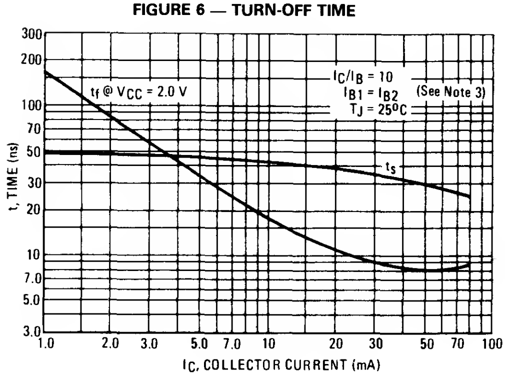


FIGURE 7 — SWITCHING TIME TEST CIRCUIT

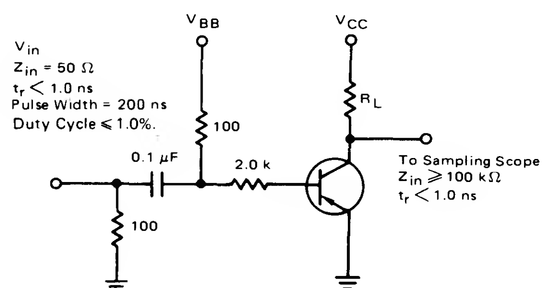
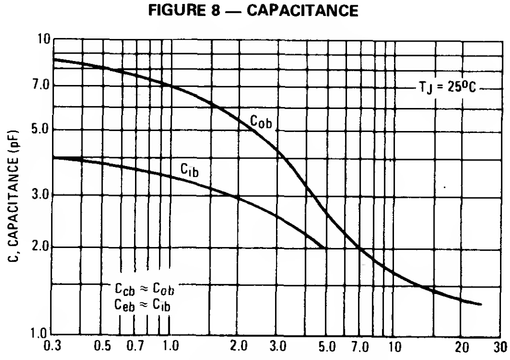


FIGURE 8 — CAPACITANCE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ ohms)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous(1)	I_C	150	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.8	Watts mW/°C
Total Device Dissipation @ $T_C = 100°C$ Derate above 100°C	P_D	0.68	Watt
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

2N914

JAN, JTX AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

4

Refer to 2N2368 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 30$ mAdc, $R_{BE} \leq 10$ ohms)	$V_{CER(sus)}$	20	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 30$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0.25$ Vdc, $T_A = 125°C$)	I_{CEX}	—	10	μAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	0.025 15	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 30 12 10	 120 — —	—
Collector-Emitter Saturation Voltage(2) ($I_C = 200$ mAdc, $I_B = 20$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ thru 20 mAdc, $T_A = -55$ to $+125°C$)	$V_{CE(sat)}$	 — —	 0.70 0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	0.70	0.80	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	9.0	pF
SWITCHING CHARACTERISTICS				
Storage Time(3) ($I_C = I_{B1} = I_{B2} = 20$ mAdc)	t_s	—	20	ns
Turn-On Time(3) ($I_C = 200$ mAdc, $I_{B1} = 40$ mAdc, $I_{B2} = 20$ mAdc)	t_{on}	—	40	ns
Turn-Off Time(3) ($I_C = 200$ mAdc, $I_{B1} = 40$ mAdc, $I_{B2} = 20$ mAdc)	t_{off}	—	40	ns

(1) Limited by Power Dissipation.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 1.0%.
(3) Measured on Sampling Scope: Pulse Width ≥ 200 ns.

2N915

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

Refer to 2N3946 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	70	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.05	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.81	Watts mW/°C
Total Power Dissipation @ + 100°C Case	P_D	0.68	W
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mA I_B = 0)	$V_{CEO(sus)}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μ A I_E = 0)	$V_{(BR)CBO}$	70	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 V, I_E = 0)	I_{CBO}	—	0.010	μA
Collector Cutoff Current (V_{CB} = 60 V, I_E = 0) (V_{CB} = 60 V, I_E = 0, T_A = +150°C)	I_{CBO}	 — —	 0.010 30	μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mA V_{CE} = 5.0 V)	h_{FE}	50	200	—
Collector-Emitter Saturation Voltage (I_C = 10 mA I_B = 1.0 mA	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mA I_B = 1.0 mA)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (I_E = 0 V_{CB} = 10 V, f = 100 kHz)	C_{obo}	—	3.5	pF
Emitter Transition Capacitance (I_C = 0 V_{EB} = 0.5 V, f = 100 kHz)	C_{TE}	—	10	pF
Input Impedance (I_C = 1.0 mA V_{CE} = 5.0 V) (I_C = 5.0 mA V_{CE} = 5.0 V)	h_{ie}	 — —	 6000 2000	ohms
High Frequency Current Gain f = 100 MHz (I_C = 10 mA V_{CE} = 15 V)	h_{fe}	2.5	—	—
Small-Signal Current Gain f = 1 kHz (I_C = 1.0 mA V_{CE} = 5.0 V) (I_C = 5.0 mA V_{CE} = 5.0 V)	h_{fe}	 40 50	 200 250	—
Output Admittance (I_C = 1.0 mA V_{CE} = 5.0 V) (I_C = 5.0 mA V_{CE} = 5.0 V)	h_{oe}	 — —	 75 125	 μmhos μmho
Collector Base Time Constant (I_C = 10 mA, V_{CB} = 10 V, f = 40 mHz)	$rb'C_c$		300	ps

(1) Pulse Test: PW ≦ 300 μs, Duty Cycle ≦ 1.0%.

2N916

JAN AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3946 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 30$ mA, $I_B = 0$)	$V_{CEO(sus)}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu A$, $I_E = 0$)	$V_{(BR)CBO}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ V, $I_E = 0$)	I_{CBO}	—	10	nAdc
Collector Cutoff Current @ 150°C ($V_{CB} = 30$ V, $I_E = 0$)	I_{CBO}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 10$ mA, $V_{CE} = 1.0$ V) ($I_C = 10$ mA, $V_{CE} = 1.0$ V, −55°C)	h_{FE}	 50 15	 200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 5.0$ V, $I_E = 0$)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5$ V, $I_C = 0$)	C_{ibo}	—	10	pF
Input Impedance, f = 1.0 kHz ($I_C = 1.0$ mA, $V_{CE} = 5.0$ V) ($I_C = 5.0$ mA, $V_{CE} = 5.0$ V)	h_{ie}	 — —	 6000 2000	 ohms ohms
Small-Signal Current Gain, f = 1.0 kHz ($I_C = 1.0$ mA, $V_{CE} = 5.0$ V) ($I_C = 5.0$ mA, $V_{CE} = 5.0$ V)	h_{fe}	 40 50	 200 250	—
Magnitude of Forward Circuit Transfer Ratio, Common-Emitter ($I_C = 10$ mA, $V_{CE} = 15$ V)	$\|h_{fe}\|$	3.0	—	—
Output Admittance, f = 1.0 kHz ($I_C = 1.0$ mA, $V_{CE} = 5.0$ V) ($I_C = 5.0$ mA, $V_{CE} = 5.0$ V)	h_{oe}	 — —	 75 125	 μmho μmho
Collector Base Time Constant ($I_C = 10$ mA, $V_{CB} = 10$ V, f = 40 MHz)	$r_b'C_c$	—	300	ps

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

4

2N918

JAN, JTX, JTXV AVAILABLE
CASE 20-03, STYLE 10
(TO-72 (TO-206AF)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	.010 1.0	μAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) (V_{CB} = 0, I_E = 0, f = 140 kHz)	C_{obo}	 — —	 1.7 3.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_G = 400 Ohms, f = 60 MHz)	NF	—	6.0	dB
FUNCTIONAL TEST				
Amplifier Power Gain (V_{CB} = 12 Vdc, I_C = 6.0 mAdc, f = 200 MHz)	G_{pe}	15	—	dB
Power Output (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	P_o	30	—	mW
Collector Efficiency (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	η	25	—	%

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N930,A

JAN, JTX AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N930	2N930A	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CBO}	45	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current	I_C	30		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 3.33		W mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 12		Watt mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +175		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	2N930A	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	2N930 2N930A	$V_{(BR)EBO}$	5.0 6.0	— —	Vdc
Collector Cutoff Current ($V_{CE} = 5.0$ Vdc, $I_B = 0$)		I_{CEO}	—	2.0	nAdc
Collector Cutoff Current ($V_{CB} = 45$ Vdc, $I_E = 0$)	2N930 2N930A	I_{CBO}	— —	10 2.0	nAdc
Collector Cutoff Current ($V_{CE} = 45$ Vdc, $V_{BE} = 0$)	2N930 2N930A	I_{CES}	— —	10 2.0	nAdc
($V_{CE} = 45$ Vdc, $V_{BE} = 0$, $T_A = 170°C$)	2N930 2N930A		— —	10 2.0	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	2N930 2N930A	I_{EBO}	— —	10 2.0	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	2N930A	h_{FE}	60	—	—
($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	2N930 2N930A		100	300	
($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$)	2N930 2N930A		20 30	— —	
($I_C = 500\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	2N930 2N930A		150 —	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) (1)	2N930 2N930A		— —	600 600	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N930 2N930A	$V_{CE(sat)}$	— —	1.0 0.5	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N930 2N930A	$V_{BE(sat)}$	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)	2N930 2N930A	f_T	30 45	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	2N930 2N930A	C_{obo}	— —	8.0 6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{rb}	—	600	X 10^{-6}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N930 2N930A	h_{fe}	150	600	—
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	—	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz)	2N930, 2N930A	NF	—	3.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

2N956

For Specifications, See 2N718A Data.

MAXIMUM RATINGS

Rating	Symbol	2N1132	2N1132A	Unit
Collector-Emitter Voltage	V_{CEO}	35	40	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ Ohms)	V_{CER}	← 50 →		Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	← 5.0 →		Vdc
Collector Current — Continuous	I_C	← 600 →		mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	← 600 → ← 3.43 →		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	← 2.0 → ← 11.43 →		Watts mW/°C
Total Device Dissipation @ $T_C = 100°C$ 2N1132A	P_D	← 1.0 →		Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.49	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	291.55	°C/W

2N1132,A

JAN AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

4

Refer to 2N2904 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	2N1132A 2N1132	$V_{(BR)CEO}$	40 35	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	2N1132, 2N1132A	$V_{(BR)CBO}$	50 60	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$) ($I_E = 1.0$ mA, $I_C = 0$)	2N1132, 2N1132A	$V_{(BR)EBO}$	5.0 5.0	— —	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$) ($V_{CB} = 45$ Vdc, $I_E = 0$) ($V_{CB} = 45$ Vdc, $I_E = 0$, $T_A = 150°C$)	2N1132 2N1132 2N1132 2N1132A 2N1132A	I_{CBO}	— — — — —	1.0 100 100 0.5 50	μAdc
Collector Cutoff Current ($V_{CE} = 50$ V, $R_{BE} = \leq 10$ Ohms)	2N1132 2N1132A	I_{CER}	— —	10 10	mA mA
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$) ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	2N1132A 2N1132	I_{EBO}	— —	100 100	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25 30	— 90	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{BE(sat)}$	—	1.3	Vdc

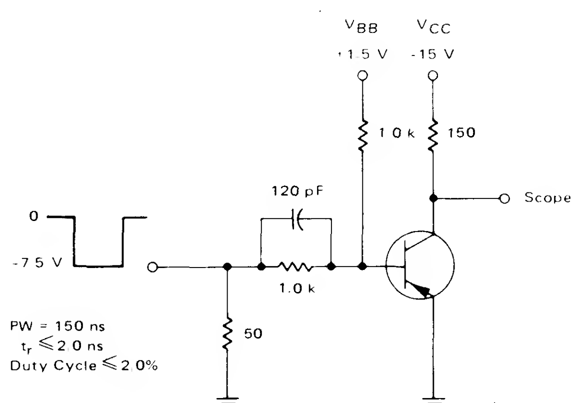
4

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	60	—	MHz
Output Capacitance		C_{obo}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N1132,		—	45	
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N1132A		—	30	
Input Capacitance		C_{ibo}			pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 kHz)	2N1132,		—	80	
(V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N1132A		—	80	
Input Impedance		h_{ib}			Ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz			25	35	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz			—	10	
Voltage Feedback Ratio		h_{rb}			X 10^{-4}
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)			—	8.0	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			—	8.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1132,		25	100	
	2N1132A		25	75	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N1132,		30	—	
	2N1132A		30		
Output Admittance		h_{ob}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)			—	1.0	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			—	5.0	
SWITCHING CHARACTERISTICS					
Turn-On Time	2N1132A	t_{on}	—	45	ns
Turn-Off Time	2N1132A	t_{off}	—	35	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 SWITCHING TIMES TEST CIRCUIT



2N1613

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage ($R_{BE} \leq 10$ Ohms)	V_{CER}	50	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 17.15	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 100$ mAdc, $R_{BE} \leq 10$ Ohms)	$V_{CER(sus)}$	50	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 100\ \mu$Adc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20 35 20 40 20	35 50 — 80 30	— — — 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.3	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	0.78	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	60	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	10	25	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	50	80	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{rb}	— —	— —	3.0 3.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	30 35	— —	100 150	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{ob}	0.05 0.05	— —	0.5 0.5	μmhos
Noise Figure ($I_C = 0.3$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 510$ Ohms, f = 1.0 kHz, Bandwidth = 1.0 Hz)	NF	—	—	12	dB
SWITCHING CHARACTERISTICS					
Switching Time	$t_d + t_r + t_f$	—	—	30	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu$s, Duty Cycle $\leq 2.0\%$.

2N1893

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

4

2N1711

For Specifications, See 2N718A Data.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, R_{BE} = 10 ohms)	$V_{CER(sus)}$	100	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.01 15	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20 35 20 40	— — — 120	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	— —	1.2 5.0	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	— —	0.9 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{obo}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{ibo}	—	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{rb}	— —	1.25 1.5	$X 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30 45	100 —	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ob}	— —	0.5 0.5	μmho

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Emitter Voltage, $R_{BE} \leq 10$ Ohms	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W

2N2102

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, $R_{BE} \leq 10$ ohms)	$V_{CER(sus)}$	80	—	—	Vdc
Collector-Emitter Sustaining Voltage(2) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	65	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 1.5 Vdc)	$V_{(BR)CEX}$	120	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	120	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	— —	2.0 2.0	nAdc μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	2.0	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(2) (I_C = 500 mAdc, V_{CE} = 10 Vdc)(2) (I_C = 1.0 Adc, V_{CE} = 10 Vdc)(2)	h_{FE}	20 35 20 40 25 10	— — — — — —	— — — 120 — —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.15	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	0.88	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	6.0	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	50	80	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{rb}	— —	— —	3.0 3.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30 35	— —	100 150	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ob}	0.01 0.01	— —	0.5 1.0	μmho
Noise Figure (I_C = 300 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k Ohm, f = 1.0 kHz, Bandwidth = 1.0 Hz)	NF	—	4.0	6.0	dB
SWITCHING CHARACTERISTICS					
Switching Time	$t_d + t_r + t_f$	—	—	30	ns

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board. (2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

2N2193A

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	8.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.8 16	Watts mW/°C
Total Device Dissipation @ 100°C Case Derate above 100°C	P_D	 1.6 16	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 25 mA, I_B = 0)	$V_{CEO(sus)}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	8.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.010 25	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.050	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 1.0 Adc, V_{CE} = 10 Vdc)(1)	h_{FE}	 15 30 20 40 30 20 15	 — — — 120 — — —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	20	pF
Small-Signal Current Gain (I_C = 50 mA, V_{CE} = 10 V, f = 20 MHz)	h_{fe}	2.5	—	—
SWITCHING CHARACTERISTICS				
Rise Time	t_r	—	70	ns
Storage Time	t_s	—	150	ns
Fall Time	t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2218,A/2N2219,A
2N2221,A/2N2222,A
2N5581/82

JAN, JTX, JTXV AVAILABLE

2N2218,A
2N2219,A
CASE 79-02
TO-39 (TO-205AD)

2N2221,A
2N2222,A
CASE 22-03
TO-18 (TO-206AA)

2N5581
2N5582
CASE 26-03
TO-46 (TO-206AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N2218 2N2219 2N2221 2N2222	2N2218A 2N2219A 2N2221A 2N2222A	2N5581 2N5582	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	6.0	Vdc
Collector Current — Continuous	I_C	800	800	800	mAdc
		2N2218,A 2N2219,A	**2N2221,A 2N2222,A**	**2N5581 2N5582**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	0.4 2.28	0.6 3.33	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.1	1.2 6.85	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	Non-A Suffix A-Suffix, 2N5581, 2N5582	$V_{(BR)CEO}$	30 40	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	Non-A Suffix A-Suffix, 2N5581, 2N5582	$V_{(BR)CBO}$	60 75	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	Non-A Suffix A-Suffix, 2N5581, 2N5582	$V_{(BR)EBO}$	5.0 6.0	— —	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	A-Suffix, 2N5581, 2N5582	I_{CEX}	—	10	nAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	 Non-A Suffix A-Suffix, 2N5581, 2N5582 Non-A Suffix A-Suffix, 2N5581, 2N5582	I_{CBO}	 — — — —	 0.01 0.01 10 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	A-Suffix, 2N5581, 2N5582	I_{EBO}	—	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	A-Suffix	I_{BL}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	 2N2218,A, 2N2221,A, 2N5581(1) 2N2219,A, 2N2222,A, 2N5582(1)	h_{FE}	 20 35	 — —	—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2218,A, 2N2221,A, 2N5581 2N2219,A, 2N2222,A, 2N5582		25 50	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2218,A, 2N2221,A, 2N5581(1) 2N2219,A, 2N2222,A, 2N5582(1)		35 75	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582		15 35	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2218,A, 2N2221,A, 2N5581 2N2219,A, 2N2222,A, 2N5582		40 100	120 300	

4

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N2218,A, 2N2221,A, 2N5581 2N2219,A, 2N2222,A, 2N5582		20 50	— —	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2218, 2N2221 2N2219, 2N2222 2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582		20 30 25 40	— — — —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix A-Suffix, 2N5581, 2N5582	$V_{CE(sat)}$	— —	0.4 0.3	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix A-Suffix, 2N5581, 2N5582		— —	1.6 1.0	
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix A-Suffix, 2N5581, 2N5582	$V_{BE(sat)}$	0.6 0.6	1.3 1.2	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix A-Suffix, 2N5581, 2N5582		— —	2.6 2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	All Types, Except 2N2219A, 2N2222A, 2N5582	f_T	250 300	— —	MHz
Output Capacitance(3) (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	8.0	pF
Input Capacitance(3) (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	Non-A Suffix A-Suffix, 2N5581, 2N5582	C_{ibo}	— —	30 25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A 2N2219A, 2N2222A	h_{ie}	1.0 2.0	3.5 8.0	kohms
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A 2N2219A, 2N2222A		0.2 0.25	1.0 1.25	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A 2N2219A, 2N2222A	h_{re}	— —	5.0 8.0	$X\ 10^{-4}$
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A 2N2219A, 2N2222A		— —	2.5 4.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A 2N2219A, 2N2222A	h_{fe}	30 50	150 300	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A 2N2219A, 2N2222A		50 75	300 375	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A 2N2219A, 2N2222A	h_{oe}	3.0 5.0	15 35	μmhos
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A 2N2219A, 2N2222A		10 25	100 200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	A-Suffix	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)	2N2219A, 2N2222A	NF	—	4.0	dB
Real Part of Common-Emitter High Frequency Input Impedance (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 300 MHz)	2N2218A, 2N2219A 2N2221A, 2N2222A	$Re(h_{ie})$	—	60	Ohms

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(3) 2N5581 and 2N5582 are Listed C_{cb} and C_{eb} for these conditions and values.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 14)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure15)	t_s	—	225	ns
Fall Time		t_f	—	60	ns
Active Region Time Constant (I_C = 150 mAdc, V_{CE} = 30 Vdc) (See Figure 14 for 2N2218A, 2N2219A, 2N2221A, 2N2222A)		T_A	—	2.5	ns

4

FIGURE 1 – NORMALIZED DC CURRENT GAIN

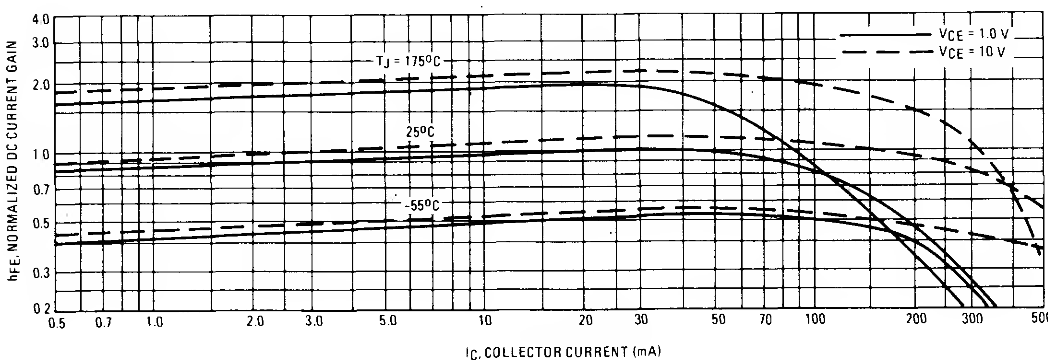
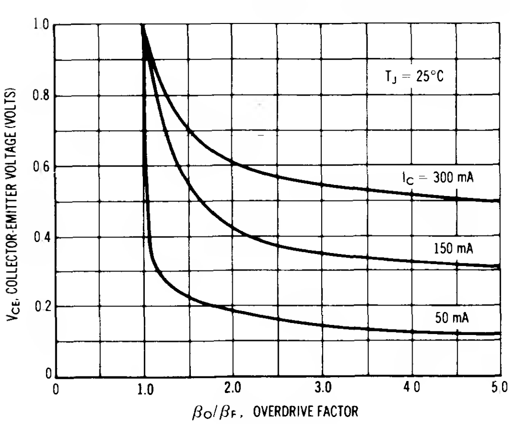


FIGURE 2 – COLLECTOR CHARACTERISTICS IN SATURATION REGION



This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit.

EXAMPLE: For type 2N2219, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at I_C = 150 mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.62 of h_{FE} @ 10 volts. Using the guaranteed minimum gain of 100 @ 150 mA and 10 V, β_O = 62 and substituting values in the overdrive equation, we find:

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1.0\,V}{I_C/I_{BF}} \qquad 2.5 = \frac{62}{150/I_{BF}} \qquad I_{BF} \approx 6.0\ \text{mA}$$

4

FIGURE 3 – "ON" VOLTAGES

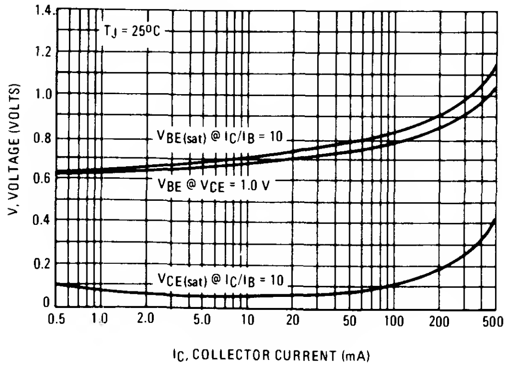
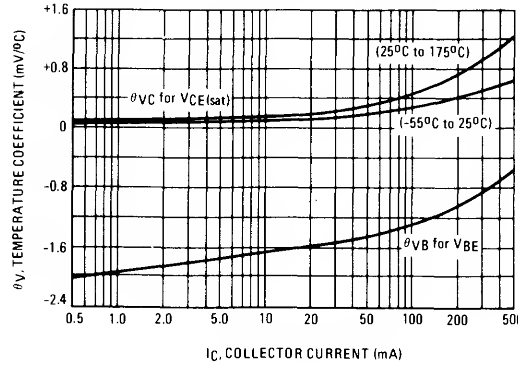


FIGURE 4 – TEMPERATURE COEFFICIENTS



h PARAMETERS

$V_{CE} = 10$ Vdc, f = 1.0 kHz, $T_A = 25^oC$

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 5 — INPUT IMPEDANCE

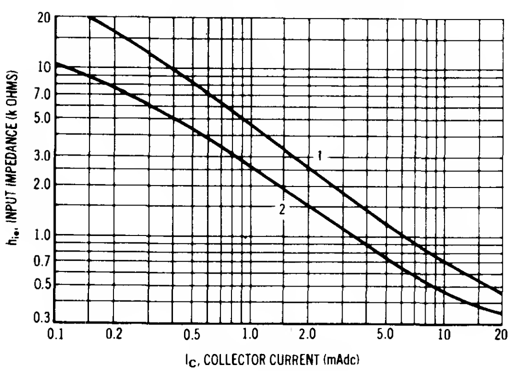


FIGURE 6 — VOLTAGE FEEDBACK RATIO

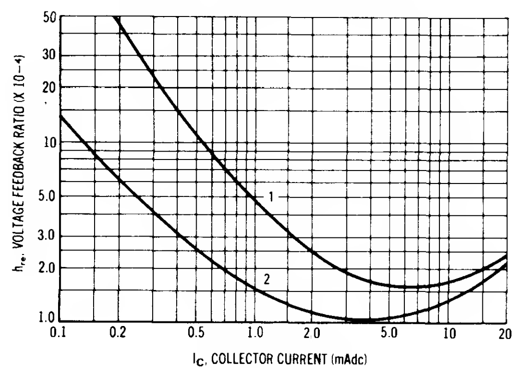


FIGURE 7 — CURRENT GAIN

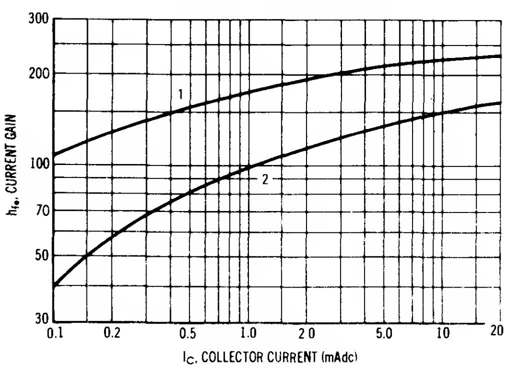
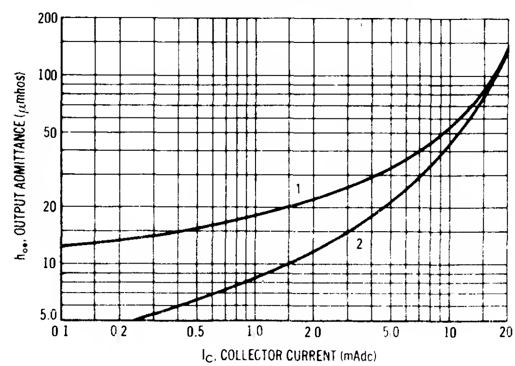


FIGURE 8 — OUTPUT ADMITTANCE



SWITCHING TIME CHARACTERISTICS

FIGURE 9 — TURN-ON TIME

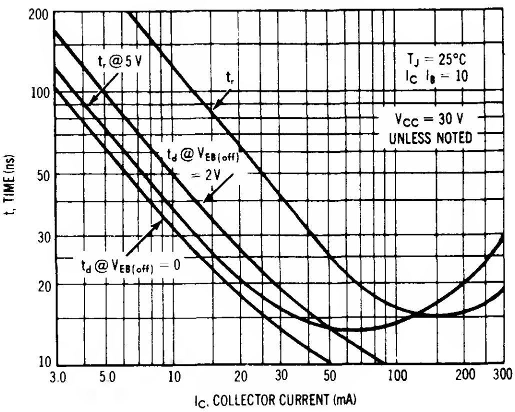


FIGURE 10 — CHARGE DATA

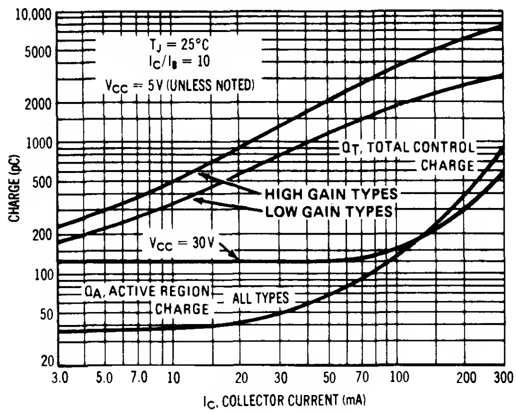
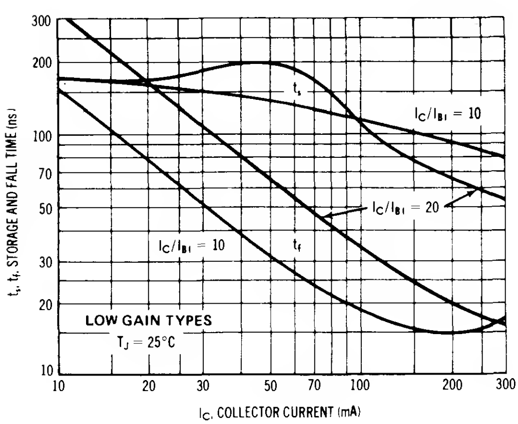


FIGURE 11 — TURN-OFF BEHAVIOR



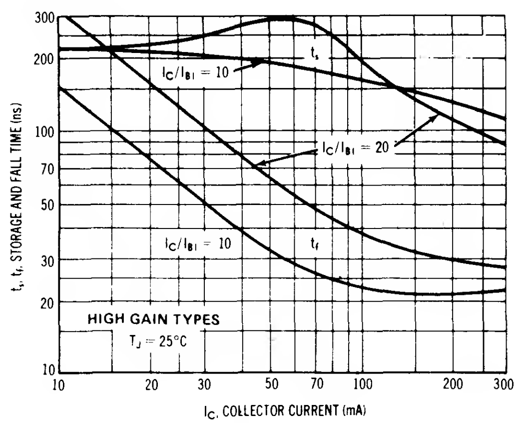


FIGURE 12 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

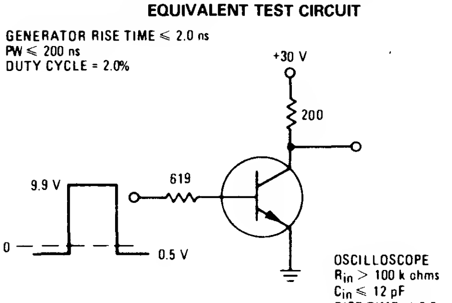
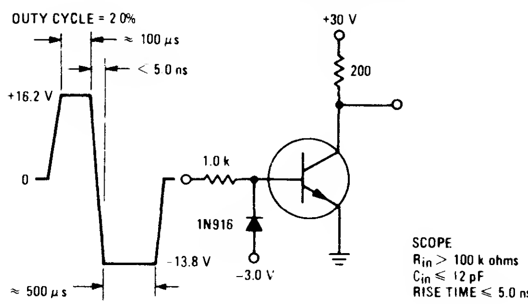


FIGURE 13 — STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



2N2270

CASE 79-02, STYLE TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Emitter Voltage, $R_{BE} \leq 10$ Ohms	V_{CER}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 100 mAdc, $R_{BE} \leq 10$ Ohms)	$V_{(BR)CER}$	60	—	—	Vdc
Collector-Emitter Sustaining Voltage(2) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	45	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.05 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0, T_C = 25°C) (V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	— —	— —	0.05 100	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 30 50	 90 135	 — 200	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.15	0.9	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	0.88	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	10	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	60	80	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	—	275	—
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 1.0 k Ohm, f = 1.0 kHz, B.W. = 1.0 Hz)	NF	—	7.0	10	dB
SWITCHING CHARACTERISTICS					
Total Switching Time	$t_{on} + t_{off}$	—	—	30	ns

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2297

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 4.56	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	219	°C/W
Lead Temperature, 1/16″ from Case for 10 seconds	T_L	300	°C

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(2) (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	35	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = +150°C)	I_{CBO}	 — —	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 Adc, V_{CE} = 10 Vdc)	h_{FE}	 30 40 15	 60 80 40	 — 120 —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	 — —	 0.1 0.6	 0.2 1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	—	0.8	1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	8.0	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	60	80	pF
Collector Base Time Constant (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 4.0 MHz)	$r_b'C_c$	—	—	800	ps

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

2N2368
2N2369,A
2N3227

2N2369A JAN, JTX, JTXV AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage 2N2368,9,A 2N3227	V_{CEO}	15 20	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage 2N2368,9,A 2N3227	V_{EBO}	4.5 6.0	Vdc
Collector Current (10 μsec pulse)	$I_{C(Peak)}$	500	mA
Collector Current — Continuous 2N2369A, 2N3227	I_C	200	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C 2N3227	P_D	1.2 6.85	Watts mW/°C
Total Device Dissipation @ $T_C = 100°C$ Derate above 100°C	P_D	.68 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, V_{BE} = 0)	2N3227	$V_{(BR)CEO}$	20	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μA, V_{BE} = 0)		$V_{(BR)CES}$	40	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	2N2368, 2N2369, 2N2369A	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μA, I_B = 0)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_E = 0)	2N2368, 2N2369, 2N2369A 2N3227	$V_{(BR)EBO}$	4.5 6.0	— —	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 3.0 Vdc)	2N3227	I_{CEX}	—	0.2	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	2N2368, 2N2369 2N3227	I_{CBO}	— —	0.4 0.2	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	2N2368, 2N2369, 2N2369A 2N3227		— —	30 50	
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	2N2369A	I_{CES}	—	0.4	μAdc
Base Current (V_{CE} = 20 Vdc, V_{BE} = 0)	2N2369A	I_B	—	0.4	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N2368 2N2369 2N2369A 2N3227	h_{FE}	20 40 — 100	60 120 120 300	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)	2N2368 2N2369 2N3227		10 20 40	— — —	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = −55°C) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc)	2N2369A 2N2369A		20 30	— —	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N2369A 2N3227		20 30	— —	
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	2N2368 2N2369		10 20	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	 2N2368, 2N2369, 2N3227 2N2369A	$V_{CE(sat)}$	 — —	 0.25 0.20	Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C) (I_C = 30 mAdc, I_B = 3.0 mAdc)	2N2369A 2N2369A		— —	0.30 0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2369A 2N3227		— —	0.50 .45	
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = −55°C) (I_C = 30 mAdc, I_B = 3.0 mAdc)	 All Types 2N2369A 2N2369A 2N2369A	$V_{BE(sat)}$	 0.70 0.59 — —	 0.85 — 1.02 1.15	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2369A 2N3227		— 0.8	1.60 1.4	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	 2N2368 2N2369, 2N2369A, 2N3227	f_T	 400 500	 — —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	All Types	C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 140 kHz)	2N3227	C_{ibo}	—	4.0	pF
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 10 V, V_{EB} = 2.0 Vdc, 100 mA, I_{B1} = 10 mA)	2N3227	t_d	—	5.0	ns
Rise Time (V_{CC} = 10 V, V_{EB} = 2.0 Vdc, 100 mA, I_{B1} = 10 mA)	2N3227	t_r	—	18	ns
Storage Time (I_C = I_{B1} = 10 mAdc, I_{B2} = −10 mAdc) (I_C = 100 mAdc, I_{B1} = I_{B2} = 10 mAdc, V_{CC} = 10 V)	 2N2368 2N2369,A 2N3227	t_s	 — — —	 10 13 13	ns
Fall Time (V_{CC} = 10 V, I_C = 100 mA, I_{B1} = I_{B2} = 10 mA)	2N3227	t_f	—	15	ns
Turn-On Time (I_C = 10 mAdc, I_{B1} = 3.0 mA, I_{B2} = −1.5 mA, V_{CC} = 3.0 Vdc)	All Types	t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 3.0 mA, I_{B2} = −1.5 mA, V_{CC} = 3.0 Vdc)	 2N2368 2N2369 2N2369A 2N3227	t_{off}	 — — — —	 — 18 15 18	ns
Total Control Charge (I_C = 10 mA, I_B = 1.0 mA, V_{CC} = 3.0 V)	2N3227	Q_T	—	50	pC

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

SWITCHING TIME EQUIVALENT TEST CIRCUITS FOR 2N2369, 2N3227

FIGURE 1 — t_{on} CIRCUIT — 10 mA

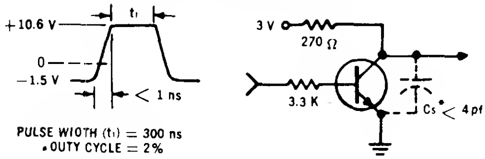


FIGURE 3 — t_{off} CIRCUIT — 10 mA

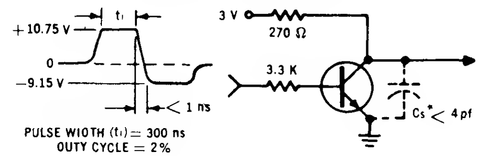


FIGURE 2 — t_{on} CIRCUIT — 100 mA

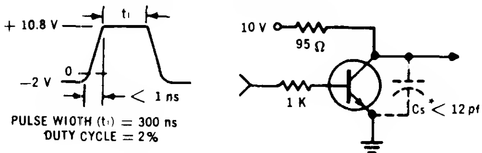
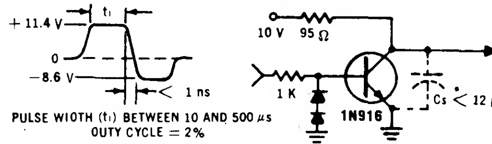


FIGURE 4 — t_{off} CIRCUIT — 100 mA



* Total shunt capacitance of test jig and connectors.

FIGURE 5 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

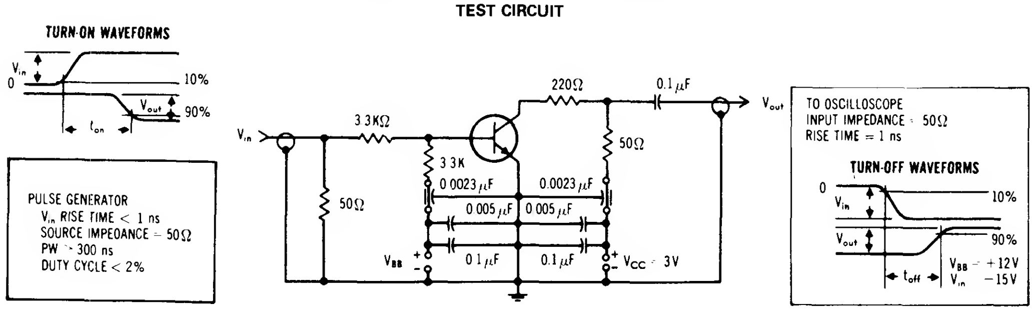


FIGURE 6 — JUNCTION CAPACITANCE VARIATIONS

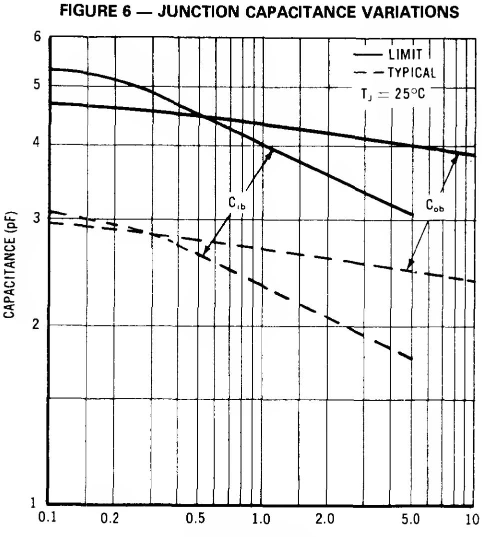


FIGURE 7 — TYPICAL SWITCHING TIMES

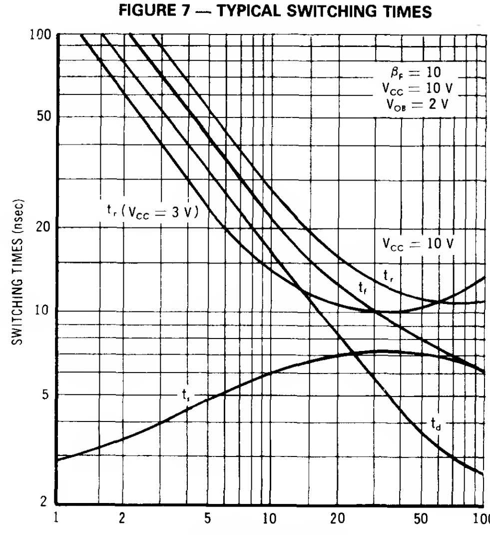


FIGURE 8 — MAXIMUM CHARGE DATA

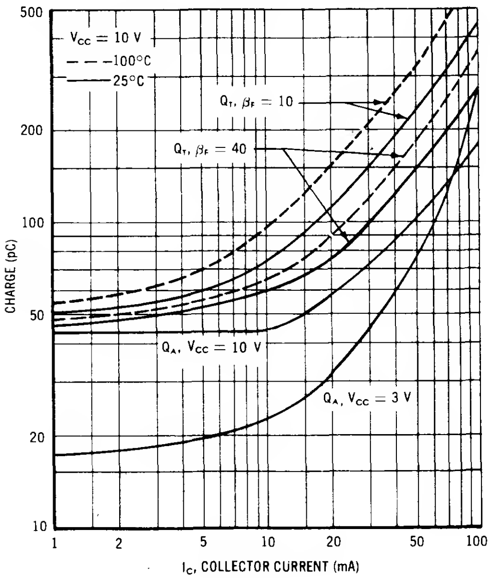


FIGURE 9 — Q_T TEST CIRCUIT

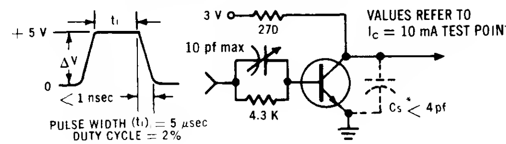


FIGURE 10 — TURN-OFF WAVE FORM

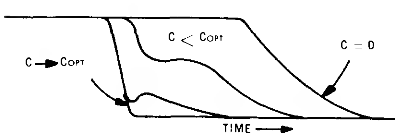


FIGURE 11 — STORAGE TIME EQUIVALENT TEST CIRCUIT

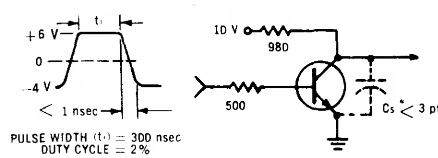


FIGURE 12 — MAXIMUM COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

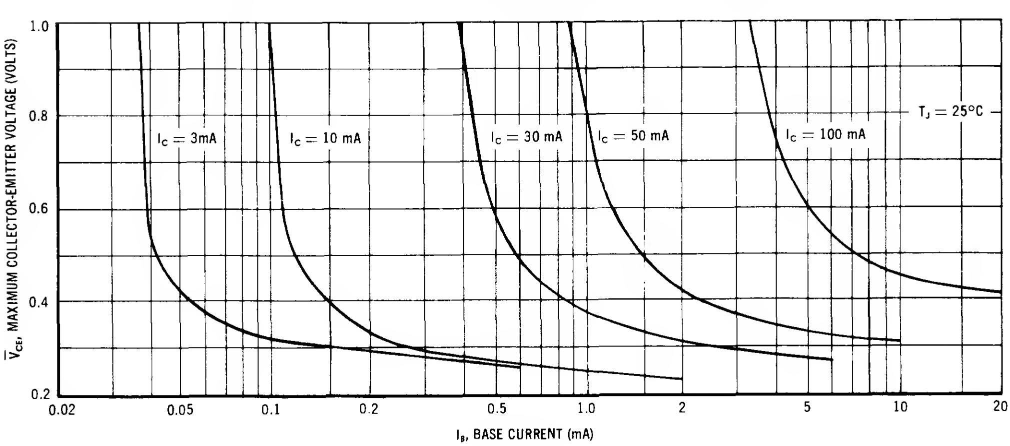


FIGURE 13 — MINIMUM CURRENT GAIN CHARACTERISTICS

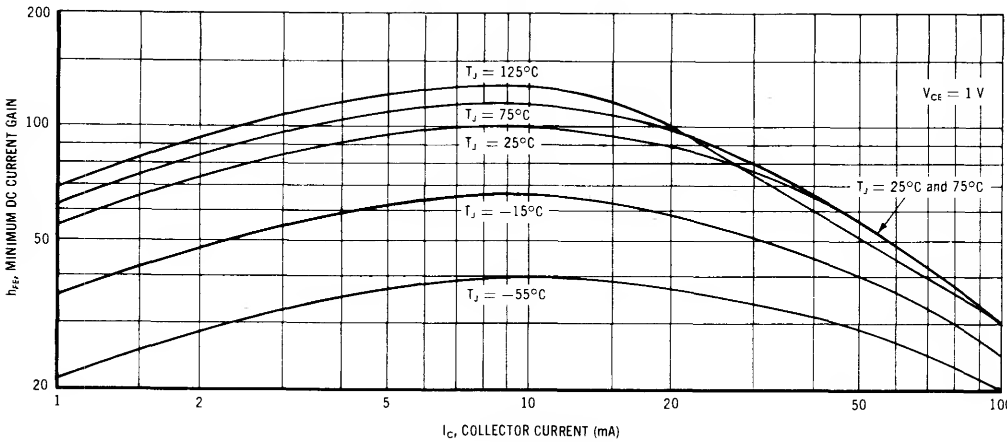


FIGURE 14 — SATURATION VOLTAGE LIMITS

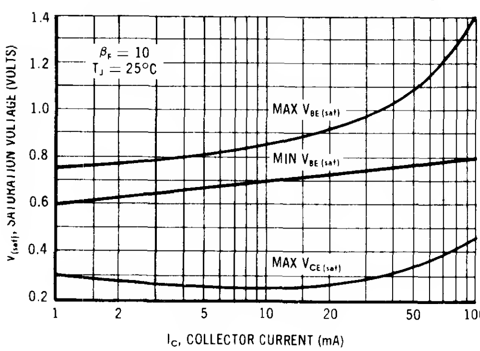
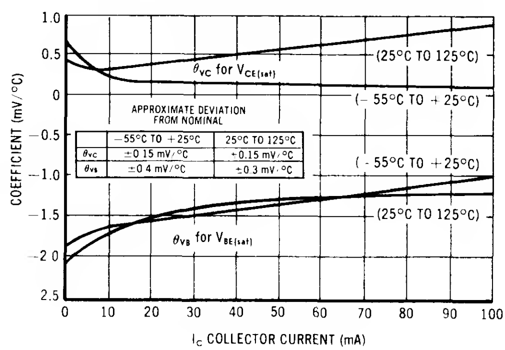


FIGURE 15 — TYPICAL TEMPERATURE COEFFICIENTS



	−55°C TO +25°C	25°C TO 125°C
θ_{VC}	±0.15 mV/°C	±0.15 mV/°C
θ_{VB}	±0.4 mV/°C	±0.3 mV/°C

2N2484

JAN, JTX, JTXV AVAILABLE
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	485	°C/W
Lead Temperature 1/16" from Case for 10 Seconds	T_L	300	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	60	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 45$ Vdc, $I_E = 0$) ($V_{CB} = 45$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0\ \mu$Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $T_A = 55°C$) ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 500\ \mu$Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)(1)	h_{FE}	30 100 20 175 200 250 —	190 250 40 275 300 350 400	— 500 — — — — 800	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	—	0.25	0.35	Vdc
Base-Emitter On Voltage ($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	0.5	0.65	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 0.05$ mAdc, $V_{CE} = 5.0$ Vdc, f = 5.0 MHz) ($I_C = 0.5$ mAdc, $V_{CE} = 5.0$ Vdc, f = 30 MHz)	f_T	15 60	50 100	— —	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	3.0	6.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	4.0	6.0	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{ie}	3.5	—	24	kΩ
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{re}	—	—	800	$X\ 10^{-6}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz	h_{fe}	150	—	900	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{oe}	—	—	40	μmhos
Noise Figure ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 100 Hz, BW = 20 Hz) ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 1.0 kHz, BW = 200 Hz) ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 10 kHz, BW = 2.0 kHz) ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 10 Hz to 15.7 kHz, BW = 15.7 kHz)	NF	— — — —	8.0 — — —	10 3.0 2.0 3.0	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2501

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.1	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0, Pulsed)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 3.0 Vdc)	I_{CEX}	—	25	nAdc
Base Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 3.0 Vdc) (V_{CE} = 20 Vdc, V_{BE} = 3.0 Vdc, T_A = 150°C)	I_{BL}	 — —	 0.025 50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 20 30 50 20 40 30 10	 — — 150 — — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 — — —	 0.2 0.3 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 — — —	 0.85 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 100 MHz)	f_T	350	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	7.0	pF
Small-Signal Current Gain (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 100 MHz)	h_{fe}	3.5	—	—

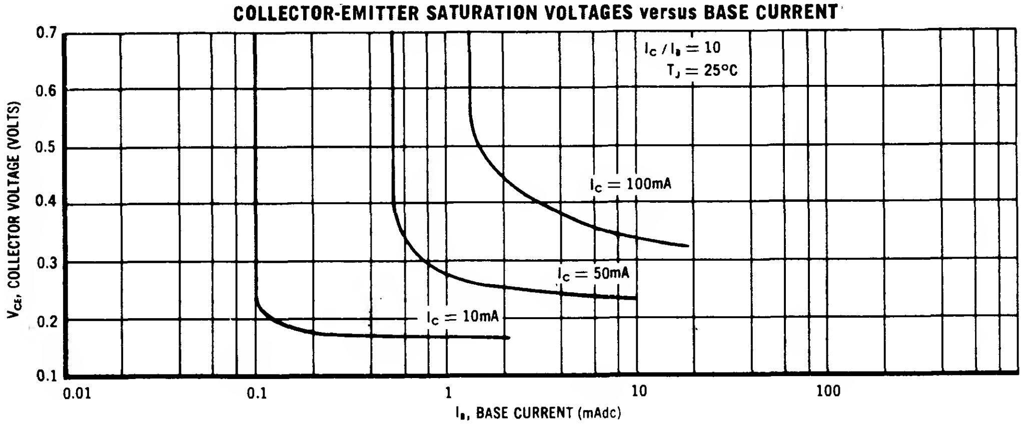
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS				
Charge Storage Time Constant ($I_C = I_{B1} = I_{B2}$ = 10 mAdc)	τ_S	—	15	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1.0 mAdc)	Q_T	—	60	pC
Active Region Time Constant (I_C = 10 mAdc)	τ_A	—	2.5	ns

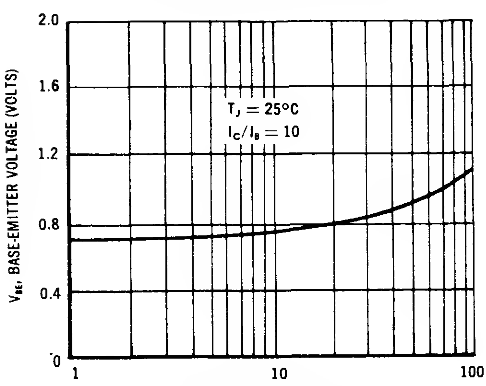
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

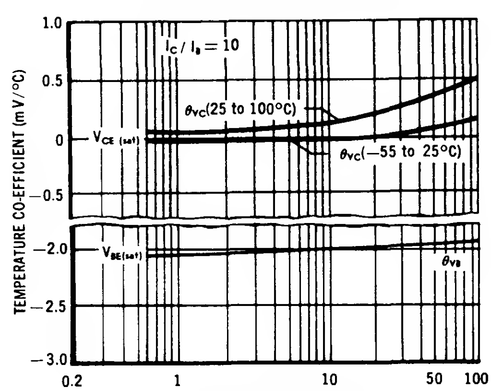
COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT



BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

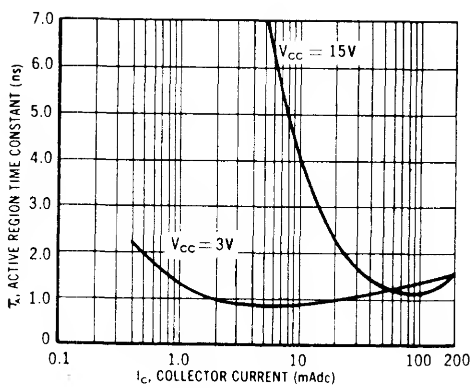


TEMPERATURE COEFFICIENTS

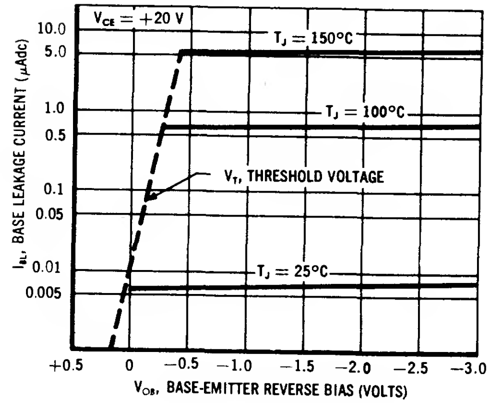


4

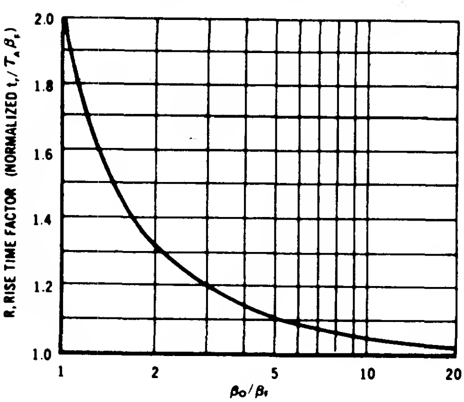
ACTIVE REGION TIME CONSTANT



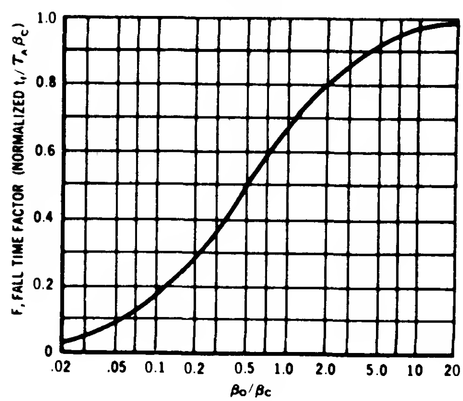
COMMON EMITTER DC LEAKAGE CHARACTERISTICS



RISE TIME FACTOR



FALL TIME FACTOR



2N2540

CASE 22, STYLE 1
TO-18

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed, I_B = 0)	$V_{(BR)CEO}$	30	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed, $R_{BE} \leq 10\ \Omega$)	$V_{(BR)CER}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc)	I_{CEX}	—	0.250	μAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.250 200	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	0.05	μAdc
Base Cutoff Current (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc) (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc, T_A = 150°C)	I_{BL}	— —	0.250 200	μAdc
ON CHARACTERISTICS(1)				
DC Forward Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	h_{FE}	35 50 100 30	— — 300 —	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	25	pF
Small-Signal Current Gain (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 MHz)	h_{fe}	2.5	—	—
SWITCHING CHARACTERISTICS				
Storage Time (I_C = I_{B1} = I_{B2} = 20 mAdc, V_{CC} = 5.0 V)	τ_S	—	20	ns
Active Region Time Constant	τ_A	—	2.0	ns
Turn-On Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, V_{CC} = 7.0 Vdc, R_L = 40 Ω)	t_{on}	—	40	ns
Turn-Off Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, V_{CC} = 7.0 Vdc, R_L = 40 Ω)	t_{off}	—	40	ns
Total Control Charge	Q_T	—	750	pC

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2605

JAN, JTX AVAILABLE
CASE 26-03, STYLE 1
TO-46 (TO-206AB)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3962 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	V
Collector-Base Voltage	V_{CBO}	60	V
Emitter-Base Voltage	V_{EBO}	6	V
Collector Current — Continuous	I_C	30	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.28	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) $I_C = 10$ mA (Pulse)	$V_{(BR)CEO}$	45	—	V
Collector-Base Breakdown Voltage ($I_C = 10\ \mu A$)	$V_{(BR)CBO}$	60	—	V
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$)	$V_{(BR)EBO}$	6	—	V
Collector Cutoff Current ($V_{CB} = 45$ V)	I_{CBO}	—	10	nA
Base-Emitter Short Circuit Current ($V_{CE} = 45$ V) ($V_{CE} = 45$ V, $T_A = 170°C$)	I_{CES}	— —	10 10	nA μA
Emitter Cutoff Current ($V_{BE} = 5.0$ V)	I_{EBO}	—	2	nA
ON CHARACTERISTICS				
DC Current Gain(1) ($V_{CE} = 5.0$ V, $I_C = 10\ \mu A$) ($V_{CE} = 5.0$ V, $I_C = 500\ \mu A$) ($V_{CE} = 5.0$ V, $I_C = 10$ mA) ($V_{CE} = 5.0$ V, $I_C = 10\ \mu A$, $T_A = -55°C$)	h_{FE}	100 150 — 20	300 — 600 —	— — — —
Collector-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 500\ \mu A$)	$V_{CE(sat)}$	—	0.5	V
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 500\ \mu A$)	$V_{BE(sat)}$	0.7	0.9	V
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 5.0$ V, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6	pF
Input Impedance ($V_{CE} = 5.0$ V, $I_C = 1.0$ mA, f = 100 MHz)	h_{ie}	—	200	Ω
Input Impedance ($V_{CB} = 5.0$ V, $I_E = 1.0$ mA, f = 1.0 kHz)	h_{ib}	25	35	Ω
Voltage Feedback Ratio ($V_{CB} = 5.0$ V, $I_E = 1.0$ mA, f = 1.0 kHz)	h_{rb}	—	10	10^{-4}
Small-Signal Current Gain ($V_{CB} = 5.0$ V, $I_E = 1.0$ mA, f = 1.0 kHz) ($V_{CB} = 5.0$ V, $I_C = 500\ \mu A$, f = 30 MHz)	h_{fe}	150 1.0	600 —	— —
Output Admittance ($V_{CB} = 5.0$ V, $I_E = 1.0$ mA, f = 1.0 kHz)	h_{ob}	—	1	μmho
Noise Figure(2) ($V_{CB} = 5.0$ V, $I_C = 10\ \mu A$, $R_g = 10$ k Ω, BW = 15.7 kHz)	NF	—	3	dB

(1) Pulse Width < 300 μsec, Duty Cycle ≤ 2.0%.
(2) Measured in amplifier with response down 3 db at 10 Hz.

2N2894

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

4

Refer to 2N869A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1200 6.85	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	—	10	μAdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)	I_{CES}	—	80	nAdc
Base Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)	I_B	—	80	nAdc
ON CHARACTERISTICS				
DC Current Gain(2) (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 30 mAdc, V_{CE} = 0.5 Vdc) (I_C = 30 mAdc, V_{CE} = 0.5 Vdc, T_A = −55°C) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)(2)	h_{FE}	 30 40 17 25	 — 150 — —	—
Collector-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 — — —	 0.15 0.2 0.5	Vdc
Base-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 0.78 0.85 —	 0.98 1.2 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{BE} = −0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	6.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 2.0 Vdc, V_{BE} = 3.0 Vdc, I_C = 30 mAdc, I_{B1} = 1.5 mAdc)	t_{on}	—	60	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc)	t_{off}	—	90	ns

(1) Applicable from 0.01 to 10 mAdc.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

2N2895
2N2896
2N2897

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N2895	2N2896	2N2897	Unit
Collector-Emitter Voltage	V_{CEO}	65	90	45	Vdc
Collector-Emitter Voltage	V_{CER}	80	140	60	Vdc
Collector-Base Voltage	V_{CBO}	120	140	60	Vdc
Emitter-Base Voltage	V_{EBO}		7.0		Vdc
Collector Current — Continuous	I_C		1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		0.5 2.86		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		1.8 10.3		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, R_{BE} = 10 ohms)	2N2895 2N2896 2N2897	$V_{(BR)CER}$	80 140 60	— — —	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	2N2895 2N2896 2N2897	$V_{CEO(sus)}$	65 90 45	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	2N2895 2N2896 2N2897	$V_{(BR)CBO}$	120 140 60	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_C = 0)	2N2895 2N2896 2N2897	I_{CBO}	— — —	0.002 0.01 0.05	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = +150°C)	2N2895 2N2897		— —	2.0 50	
(V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = +150°C)	2N2896 2N2896		— —	0.01 10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N2895 2N2896 2N2897	I_{EBO}	— — —	0.005 0.01 0.05	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 10 Vdc) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	2N2895 2N2895 2N2896, 2N2897 2N2895 2N2895, 2N2896	h_{FE}	10 20 35 35 20	— — — — —	—
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2895 2N2896 2N2897		40 60 50	120 200 200	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2895		25	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	2N2895, 2N2896 2N2897	$V_{CE(sat)}$	— —	0.6 1.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	2N2895, 2N2896 2N2897	$V_{BE(sat)}$	— —	1.2 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N2895, 2N2896 2N2897	f_T	120 100	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	80	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2895 2N2896, 2N2897	h_{fe}	50 50	200 275	—
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 500 ohms, f = 1.0 kHz, BW = 15 kHz)	2N2895	NF	—	8.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.8%.

4

2N2904,A, 2N2905,A, 2N2906,A, 2N2907,A, 2N3485,A, 2N3486,A

JAN, JTX, JTXV AVAILABLE*

CASE 79-02, STYLE 1
2N2904/2905 TO-39 (TO-205AD)
CASE 22-03, STYLE 1
2N2906/2907 TO-18 (TO-206AA)
CASE 26-03, STYLE 1
2N3485/3486 TO-46 (TO-206AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Non-A Suffix		A-Suffix	Unit
Collector-Emitter Voltage	V_{CEO}	40		60	Vdc
Collector-Base Voltage	V_{CBO}	60			Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	600			mAdc
		2N2904,A 2N2905,A	2N2906,A 2N2907,A	2N3485,A 2N3486,A	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 3.43	400 2.28	400 2.28	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	1.8 10.3	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	Non-A Suffix A-Suffix	$V_{(BR)CEO}$	40 60	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)		I_{CEX}	—	—	50	nAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	Non-A Suffix A-Suffix	I_{CBO}	— —	— —	0.020 0.010	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	Non-A Suffix A-Suffix		— —	— —	20 10	
Base Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)		I_B	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A	h_{FE}	20 35 40 75	— — — —	— — — —	—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A		25 50 40 100	— — — —	— — — —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A		35 75 40 100	— — — —	— — — —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2904A, 2N2906A, 2N3485,A 2N2905A, 2N2907A, 2N3486A		40 100	— —	120 300	

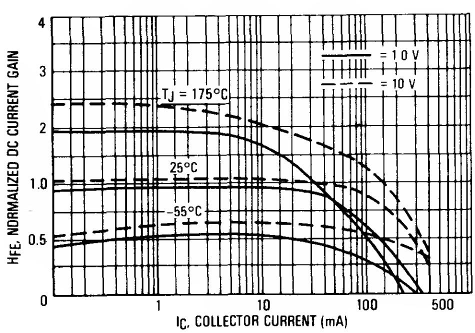
***ALSO AVAILABLE 2N2905ALJANS AND 2N2907AJANS**

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

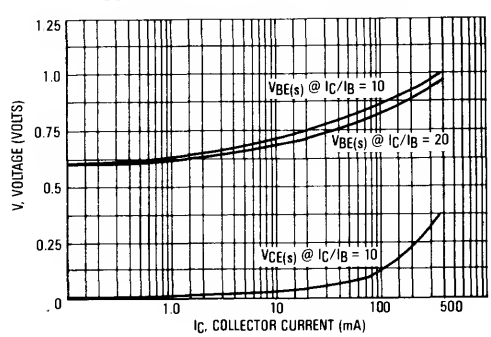
Characteristic		Symbol	Min	Typ	Max	Unit
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A		20 30 40 50	— — — —	— — — —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	 — —	 — —	 0.4 1.6	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)(1) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	 — —	 — —	 1.3 2.6	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	—	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	—	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	—	26	45	ns
Delay Time		t_d	—	6.0	10	ns
Rise Time		t_r	—	20	40	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	70	100	ns
Storage Time		t_s	—	50	80	ns
Fall Time		t_f	—	20	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0.%
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

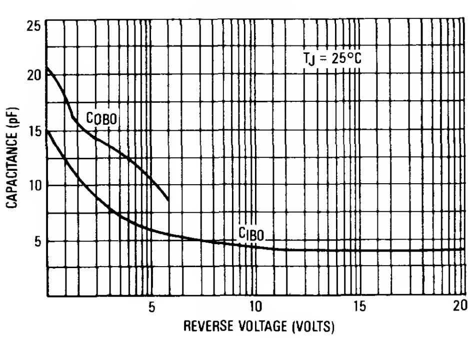
NORMALIZED DC CURRENT GAIN



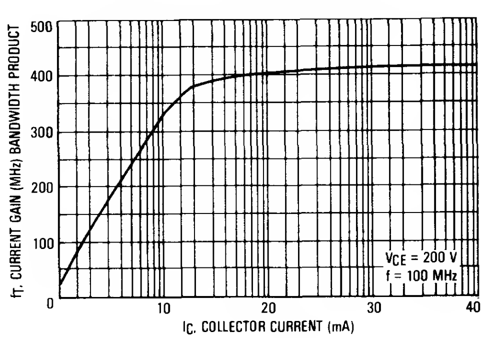
CURRENT GAIN—BANDWIDTH PRODUCT



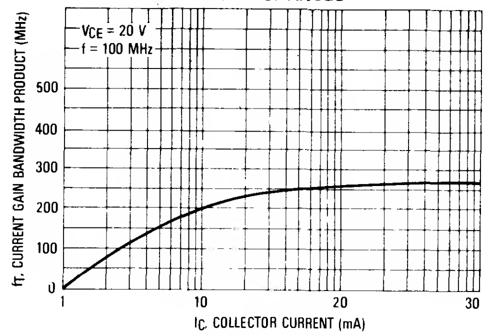
"ON" VOLTAGES



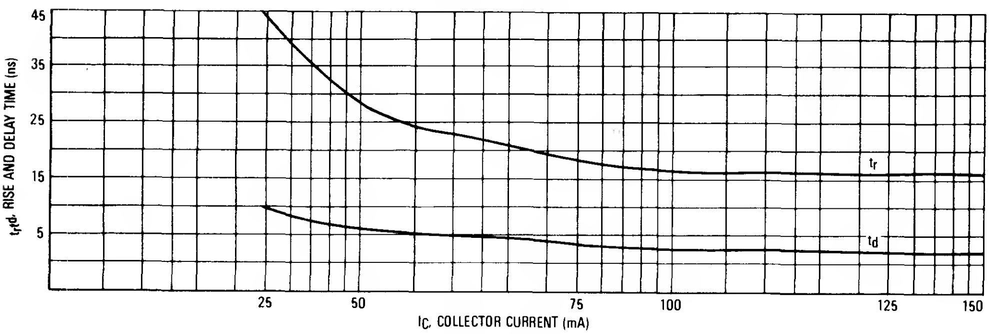
CURRENT GAIN—BANDWIDTH PRODUCT



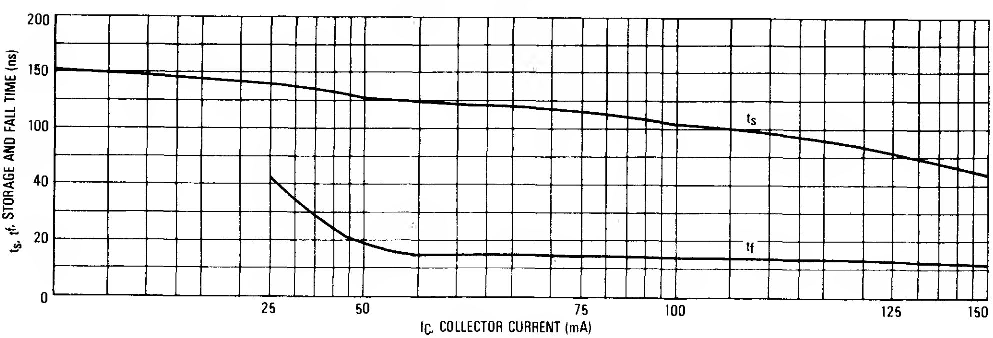
CAPACITANCES



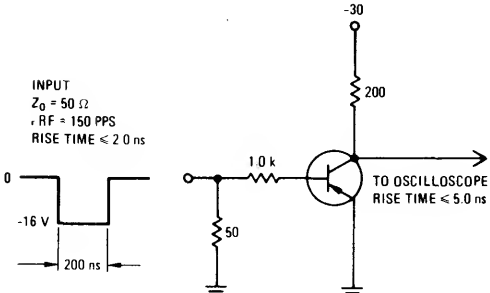
TURN ON BEHAVIOR



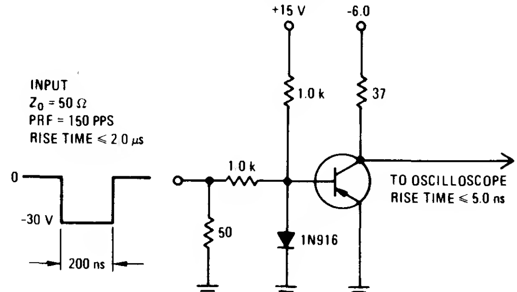
TURN OFF BEHAVIOR



DELAY AND RISE TIME TEST CIRCUIT



STORAGE AND FALL TIME TEST CIRCUIT



MAXIMUM RATINGS

Rating	Symbol	2N2944	2N2945	2N2946	Unit
Emitter-Collector Voltage	V_{ECO}	10	20	35	Vdc
Collector-Base Voltage	V_{CBO}	15	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	15	25	40	Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	400			mW
Derate above 25°C		2.3			mW/°C
Total Device Dissipation @ $T_C = 25°C$	P_D	2.0			Watts
Derate above 25°C		11.43			mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	435	°C/W

2N2944 thru 2N2946

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

TRANSISTOR

PNP SILICON

Refer to 2N2944A for graphs.

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	2N2944	I_{CBO}	—	—	0.1	nAdc
(V_{CB} = 25 Vdc, I_E = 0)	2N2945		—	—	0.2	
(V_{CB} = 40 Vdc, I_E = 0)	2N2946		—	—	0.5	
Emitter Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)	2N2944	I_{EBO}	—	—	0.1	nAdc
(V_{EB} = 25 Vdc, I_C = 0)	2N2945		—	—	0.2	
(V_{EB} = 40 Vdc, I_C = 0)	2N2946		—	—	0.5	
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)	2N2944	h_{FE}	80	180	—	—
	2N2945		40	160	—	
	2N2946		30	130	—	
*DC Current Gain (inverted connection) (I_B = 200 μAdc, V_{EC} = 0.5 Vdc)	2N2944	$h_{FE(inv)}$	6.0	20	—	—
	2N2945		4.0	17	—	
	2N2946		3.0	15	—	
Offset Voltage (I_B = 200 μAdc, I_E = 0)	2N2944	$V_{EC(ofs)}$	—	0.18	0.3	mVdc
	2N2945		—	0.23	0.5	
	2N2946		—	0.27	0.8	
(I_B = 1.0 mAdc, I_E = 0)	2N2944		—	0.4	0.6	
	2N2945		—	0.5	1.0	
	2N2946		—	0.6	2.0	
(I_B = 2.0 mAdc, I_E = 0)	2N2944		—	0.8	1.0	
	2N2945		—	0.9	1.6	
	2N2946		—	1.0	2.5	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 MHz)	2N2944	f_T	10	15	—	MHz
	2N2945		5.0	13	—	
	2N2946		3.0	12	—	
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 500 kHz)		C_{obo}	—	3.2	10	pF
Input Capacitance (V_{EB} = 6.0 Vdc, I_C = 0, f = 500 kHz)		C_{ibo}	—	1.9	6.0	pF
"ON" Series Resistance (I_B = 1.0 mAdc, I_E = 0, I_c = 100 μArms, f = 1.0 kHz)	2N2944	r_{ec}	—	4.0	20	Ohms
	2N2945		—	4.5	35	
	2N2946		—	5.0	45	

*Indicates Data in addition to JEDEC Requirements.

2N2944A
2N2945A
2N2946A

JAN, JTX, JTXV AVAILABLE
CASE 26-03, STYLE 1
TO-46 (TO-205AB)

CHOPPER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N2944A	2N2945A	2N2946A	Unit
Emitter-Collector Voltage	V_{ECO}	10	20	35	Vdc
Collector-Base Voltage	V_{CBO}	15	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	15	25	40	Vdc
Collector Current — Continuous	I_C		100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		400 2.3		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		2.0 11.43		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C
Lead Temperature 1/16″ from Case for 10 seconds	T_L		240		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	435	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	87.5	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Emitter-Collector Breakdown Voltage (I_E = 10 μAdc, I_B = 0)	2N2944A 2N2945A 2N2946A	$V_{(BR)ECO}$	10 20 35	— — —	— — —	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 25 Vdc, I_E = 0)	2N2944A 2N2945A	I_{CBO}	— —	— —	0.1 0.2	nAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N2946A		—	—	0.5	
(V_{CB} = 15 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 25 Vdc, I_E = 0, T_A = 100°C)	2N2944A 2N2945A		— —	— —	10 20	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	2N2946A		—	—	25	
Emitter Cutoff Current (V_{EB} = 25 Vdc, I_C = 0)	2N2944A 2N2945A	I_{EBO}	— —	— —	0.1 0.2	nAdc
(V_{EB} = 40 Vdc, I_C = 0)	2N2946A		—	—	0.5	
(V_{EB} = 25 Vdc, I_C = 0, T_A = 100°C)	2N2944A 2N2945A		— —	— —	10 15	
(V_{EB} = 40 Vdc, I_C = 0, T_A = 100°C)	2N2946A		—	—	20	
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)	2N2944A 2N2945A 2N2946A	h_{FE}	100 70 50	— 200 200	— — —	—
DC Current Gain (Inverted Connection) (I_B = 200 μAdc, V_{EC} = 0.5 Vdc)	2N2944A 2N2945A 2N2946A	$h_{FE(inv)}$	50 30 20	— 32 25	— — —	—
Offset Voltage (I_B = 200 μAdc, I_E = 0)	2N2944A 2N2945A 2N2946A	$V_{EC(ofs)}$	— — —	0.23 0.4 0.7	0.3 0.5 0.8	mVdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
(I_B = 1.0 mAdc, I_E = 0)	2N2944A		—	—	0.6	
	2N2945A		—	0.5	1.0	
	2N2946A		—	0.6	2.0	
(I_B = 2.0 mAdc, I_E = 0)	2N2944A		—	—	1.0	
	2N2945A		—	0.9	1.6	
	2N2946A		—	1.0	2.5	

SMALL-SIGNAL CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 MHz)	2N2944A		—	—	—	
	2N2945A		10	15	—	
	2N2946A		5.0	8.0	—	
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 0.1 MHz to 1.0 MHz)		C_{obo}	—	3.2	10	pF
Input Capacitance (V_{EB} = 6.0 Vdc, I_C = 0, f = 0.1 MHz to 1.0 MHz)		C_{ibo}	—	1.9	6.0	pF
"ON" Series Resistance		$r_{ec(on)}$				Ohms
(I_B = 1.0 mAdc, I_E = 0, I_e = 100 μArms, f = 1.0 kHz)	2N2944A		—	—	4.0	
	2N2945A		—	5.0	6.0	
	2N2946A		—	7.0	8.0	

FIGURE 1 — $V_{EC(on)}$

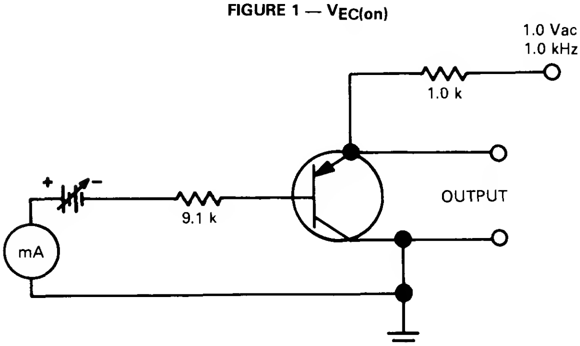
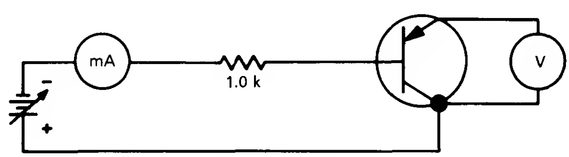


FIGURE 2 — V_{EC}(offset)



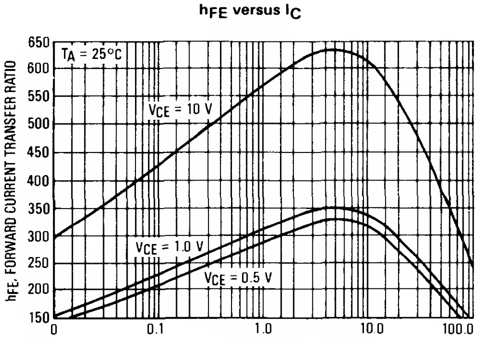
mA + + + + + - - - - - - 9.1 k 2% 1.0 Vac

10 k 2% Output Figure 1 — rec(on) $r_{ec(on)}$ $r_{ec(on)}$

mA 1.0k 2% V

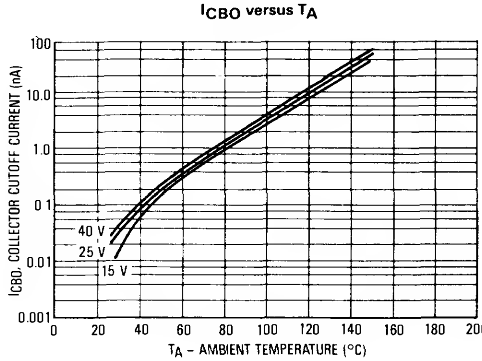
Output measured with H.P. 400D
Ac VTVM or equivalent.
1.0 mV = 1.0 Ω rec(on)

h_{FE} versus I_C



*NOTE:
PULSE WIDTH = 300 μs,
DUTY CYCLE ≤ 2%

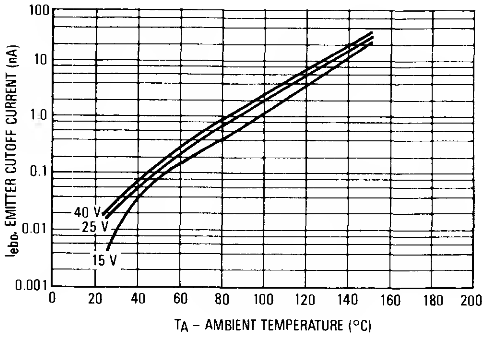
I_{CBO} versus T_A



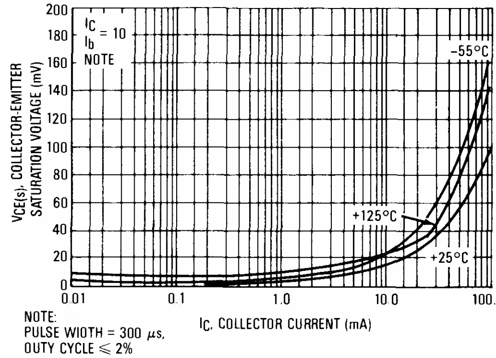
2N2944A, 2N2945A, 2N2946A

4

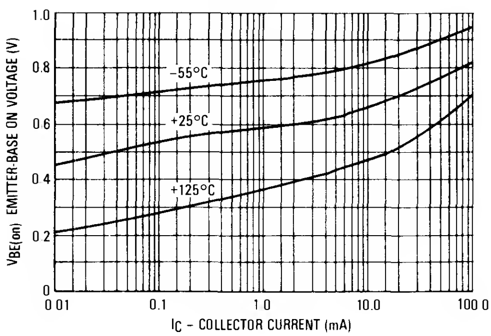
I_{ebo} versus T_A



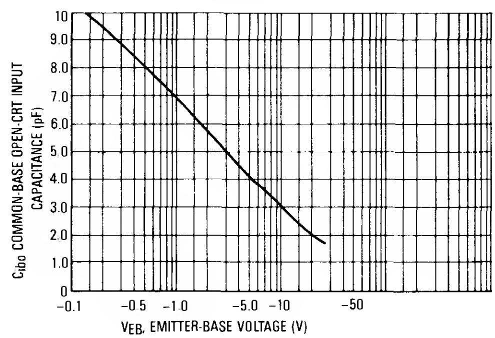
$V_{CE(s)}$ versus I_C



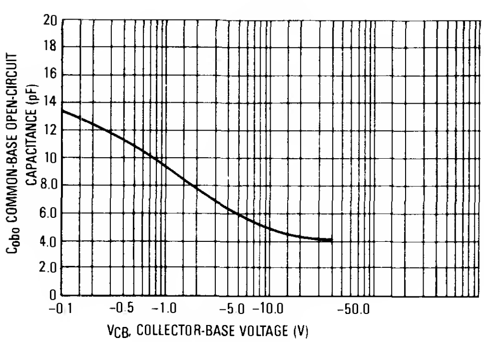
$V_{BE(on)}$ versus I_C



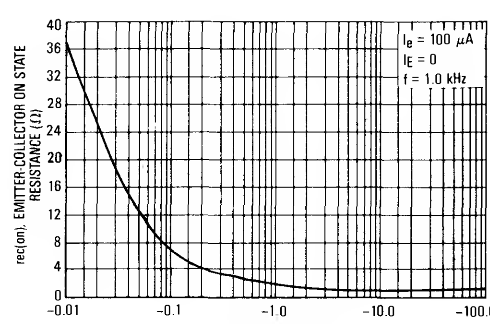
C_{ibo} versus V_{EB}



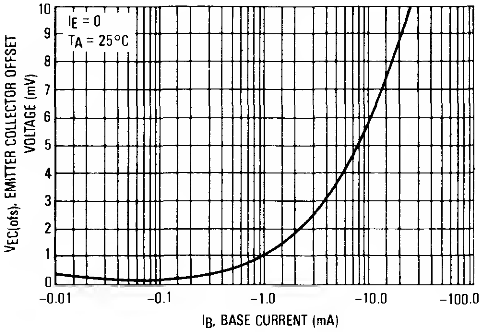
C_{obo} versus V_{CB}



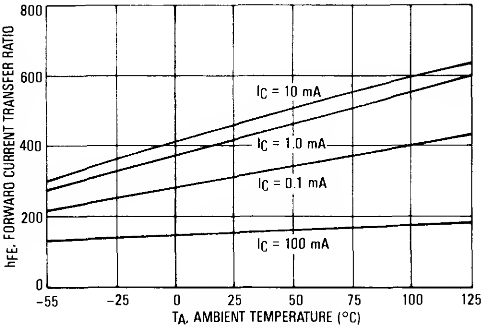
rec(on) versus I_B



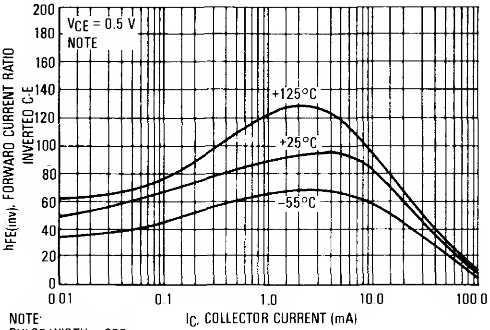
$V_{EC(ofs)}$ versus I_B



h_{FE} versus T_A



$h_{FE(inv)}$, versus I_C



NOTE:
PULSE WIDTH = 300 μs,
DUTY CYCLE ≤ 2%

2N2959

CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTORS

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 20	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 4.00	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, pulsed, I_B = 0)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)	I_{CEX}	—	.050	μAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.025 15	μAdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)	I_{BL}	—	.050	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	300	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mA, V_{CE} = 20 V, f = 100 MHz)	f_T	250	—	MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 100 kHz)	C_{obo}	—	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_d	—	20	ns
Rise Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_r	—	75	ns
Storage Time (V_{CC} = 6.0 V, I_{CS} = 150 mA, I_{B1} = 15 mA, I_{B2} = 15 mA)	t_s	—	300	ns
Fall Time (V_{CC} = 6.0 V, I_{CS} = 150 mA, I_{B1} = 15 mA, I_{B2} = 15 mA)	t_f	—	200	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	12	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous Peak (10 μs Pulse)	I_C	200 500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.20 0.68 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

2N3011

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

4

Refer to 2N2368 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc V_{BE} = 0) (V_{CE} = 20 Vdc, V_{BE} = 0, T_A = +85°C)	I_{CES}	— —	0.4 10	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	I_{BL}	—	0.4	μAdc
ON CHARACTERISTICS (2)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.35 Vdc) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 25 12	120 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +85°C)	$V_{CE(sat)}$	— — — —	0.20 0.25 0.50 0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	0.72 — —	0.87 1.15 1.60	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	4.0	pF
SWITCHING CHARACTERISTICS				
Storage Time (I_C = I_{B1} = $-I_{B2}$ = 10 mAdc)	t_s	—	13	ns
Turn-On Time (V_{CC} = 2.0 Vdc, $V_{EB(off)}$ = 0, I_C = 30 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	15	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = $-I_{B2}$ = 3.0 mAdc)	t_{off}	—	20	ns

(1) Applicable from 0.01 mA to 10 mA (Pulsed).
(2) Pulse Test: Pulse Length = 30 μs, Duty Cycle ≤ 2.0%.

2N3012

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N869A for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0) (Emitter-Base Termination — Open Base)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0) (V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = +85°C)	I_{CES}	— —	80 5.0	μAdc
Base Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)	I_B	—	30	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 30 mAdc, V_{CE} = 0.5 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)(1)	h_{FE}	 25 30 20	 — 120 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +85°C) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 — — — —	 0.15 0.2 0.4 0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 0.78 0.85 —	 0.98 1.2 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	6.0	pF
Small-Signal Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	4.0	—	—
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 2.0 Vdc, $I_C \approx 30$ mAdc, $I_{B1} \approx 1.5$ mAdc)	t_{on}	—	60	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, $I_C \approx 30$ mAdc, $I_{B1} = I_{B2} \approx 1.5$ mAdc)	t_{off}	—	75	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1) 2N3013 2N3014	V_{CEO}	 15 20	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous (10 μs pulse) Peak	I_C	200 500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C @ T_C = 100°C Derate above 25°C	P_D	1.20 0.68 6.85	Watts Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

(1) Applicable from 0.01 mA to 10 mA (Pulsed)

2N3013
2N3014

2N3013 JAN, JTX AVAILABLE
CASE 27, STYLE 1
TO-52 (TO-206AC)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N3510 for graphs.

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		$V_{(BR)CES}$	40	—	Vdc
Collector-Emitter Sustaining Voltage(2) (I_C = 10 mAdc, I_B = 0)	 2N3013 2N3014	$V_{CEO(sus)}$	 15 20	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	— —	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0) (V_{CE} = 20 Vdc, V_{BE} = 0, T_A = +125°C)		I_{CES}	 — —	 0.3 40	μAdc
Base Current (V_{CE} = 20 Vdc, V_{BE} = 0)		I_B	—	0.3	μAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 0.5 Vdc) (I_C = 10 mAdc, V_{CE} = 0.4 Vdc) (I_C = 300 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc, T_A = −55°C)	 2N3013 2N3014 2N3013 2N3014	h_{FE}	 30 25 25 15 25 12	 120 — — — — —	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +125°C)	 2N3013 2N3014 2N3013 2N3014	$V_{CE(sat)}$	 — — — — — —	 0.18 0.28 0.35 0.50 0.18 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc)	 2N3013 2N3014	$V_{BE(sat)}$	 0.75 — — 0.70	 0.95 1.20 1.70 0.80	Vdc

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	8.0	pF
SWITCHING CHARACTERISTICS				
Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	t_s	—	18	ns
Turn-On Time	t_{on}			ns
($V_{EB(off)}$ = 5.0 V, V_{CC} = 15 V, I_C = 300 mAdc, I_{B1} = 30 mAdc) 2N3013		—	15	
($V_{EB(off)}$ = 0, V_{CC} = 2.0 V, I_C = 30 mAdc, I_{B1} = 3.0 mAdc) 2N3014		—	16	
Turn-Off Time	t_{off}			ns
(V_{CC} = 15 V, I_C = 300 mAdc, I_{B1} = I_{B2} = 30 mAdc) 2N3013		—	25	
(V_{CC} = 2.0 V, I_C = 30 mAdc, I_{B1} = I_{B2} = 3.0 mAdc) 2N3014		—	25	

(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

4

MAXIMUM RATINGS

Rating	Symbol	2N3019 2N3020	2N3700	Unit
Collector-Emitter Voltage	V_{CEO}	80	80	Vdc
Collector-Base Voltage	V_{CBO}	140	140	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	7.0	Vdc
Collector Current — Continuous	I_C	1.0	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6	0.5 2.85	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	1.8 10.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3019 2N3020	2N3700	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	16.5	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	89.5	245	°C/W

2N3019
2N3020
2N3700

JAN, JTX, JTXV AVAILABLE
2N3019, 2N3020
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

2N3700
CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0)		$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	140	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = +150°C)		I_{CBO}	 — —	 0.01 10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	 2N3700, 2N3019 2N3020	h_{FE}	 50 30	 — 100	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3700, 2N3019 2N3020		90 40	— 120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N3700, 2N3019 2N3020		100 40	300 120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc, T_C = −55°C)	2N3700, 2N3019		40	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N3700, 2N3019 2N3020		50 30	— 100	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	All Types		15	—	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	—	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	 2N3020 2N3019, 2N3700	f_T	 80 100	 — 400	MHz

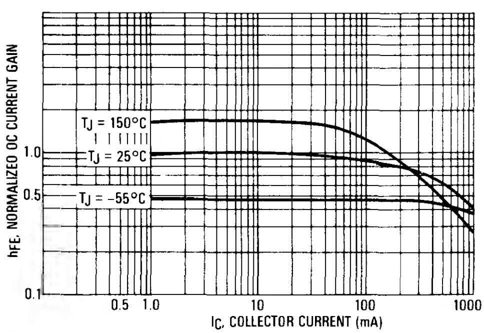
4

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

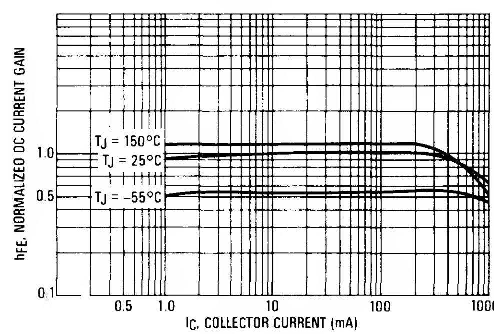
Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	60	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N3700, 2N3019 2N3020	h_{fe}	80 30	400 200	—
Collector Base Time Constant (I_E = 10 mAdc, V_{CB} = 10 Vdc, f = 4.0 MHz)	2N3019, 2N3020 2N3700	$r_b'C_c$	— 15	400 400	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)	2N3019, 2N3700	NF	—	4	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

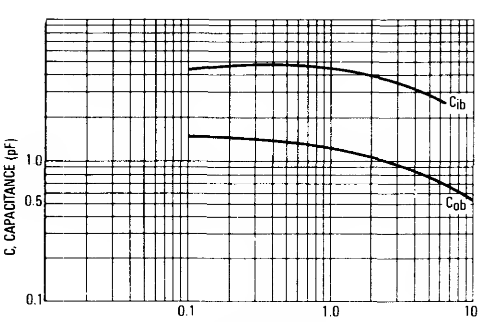
DC CURRENT GAIN
2N3019, 2N3700



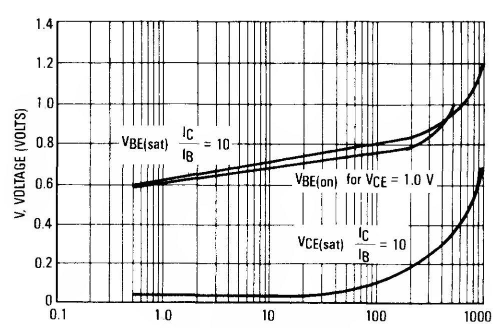
DC CURRENT GAIN
2N3020



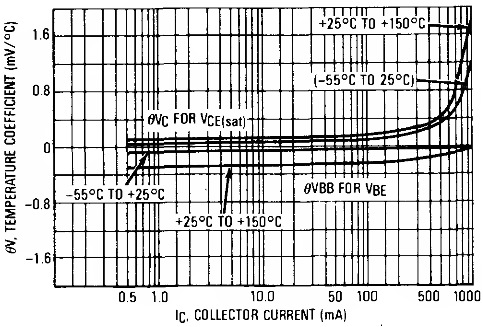
CAPACITANCE



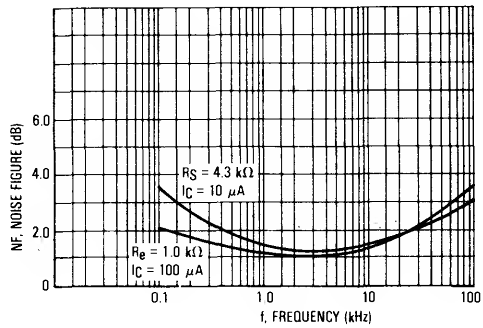
"ON" VOLTAGES



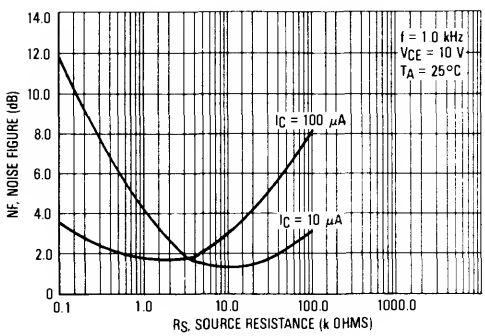
TEMPERATURE COEFFICIENTS



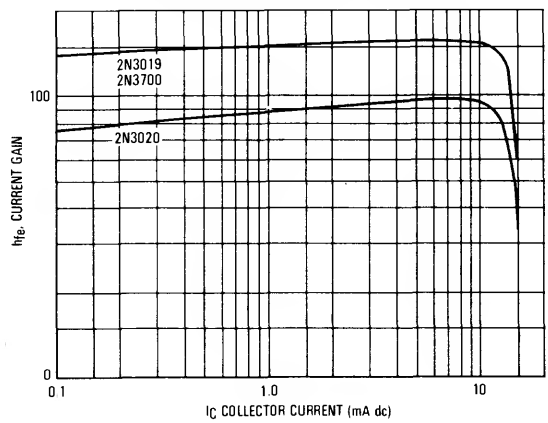
FREQUENCY EFFECTS



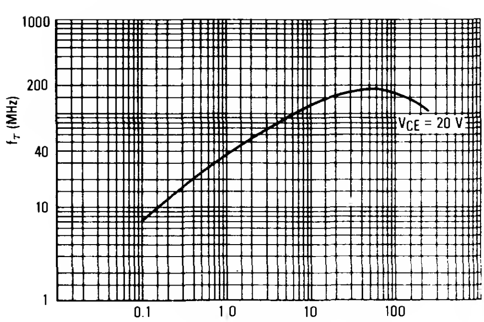
SOURCE RESISTANCE EFFECTS



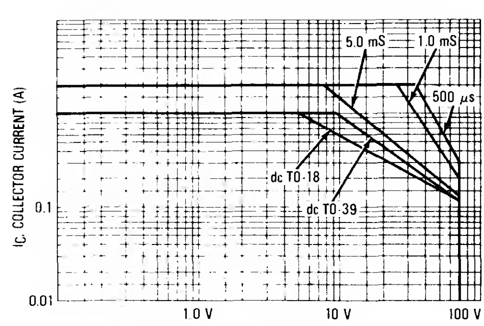
CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT — 1 kHz h_{fe}



CURRENT GAIN — BANDWIDTH PRODUCT



ACTIVE REGION SAFE OPERATING AREA



2N3053,A

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N3053	2N3053A	Unit
Collector-Emitter Voltage(1)	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	700		mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Lead Temperature 1/16", ±1/32" From Case for 10 s	T_L	+235		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

(1) Applicable 0 to 100 mA (Pulsed):
Pulse Width ≤ 300 μsec., Duty Cycle ≤ 2.0%.
0 to 700 mA; Pulse Width ≤ 10 μsec., Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 100 μAdc, I_B = 0)	2N3053 2N3053A	$V_{(BR)CEO}$	40 60	— —	Vdc
Collector-Emitter Breakdown Voltage(2) (I_C = 100 mAdc, R_{BE} = 10 ohms)	2N3053 2N3053A	$V_{(BR)CER}$	50 70	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N3053 2N3053A	$V_{(BR)CBO}$	60 80	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3053 2N3053A	I_{CEX}	—	0.25	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	2N3053	I_{EBO}	—	0.25	μAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3053A	I_{BL}	—	0.25	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 2.5 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)		h_{FE}	25 50	— 250	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	2N3053 2N3053A	$V_{CE(sat)}$	— —	1.4 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	2N3053 2N3053A	$V_{BE(sat)}$	— 0.6	1.7 1.0	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	2N3053 2N3053A	$V_{BE(on)}$	— —	1.7 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	80	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3114

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	150	Vdc
Collector-Base Voltage	V_{CBO}	150	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

Refer to 2N3498 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = = 30 mAdc, I_B = 0)	$V_{(BR)CEO}$	150	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	150	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.010 10	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	0.10	μAdc
ON CHARACTERISTICS				
DC Current Gain(2) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	h_{FE}	 15 30 12	 — 120 —	—
Collector-Emitter Saturation Voltage(2) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage(2) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	9.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	80	pF
Small-Signal Current Gain (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)	h_{fe}	25	—	—
Current Gain — High Frequency (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 20 MHz)	$\lvert h_{fe} \rvert$	2.0	—	—
Real Part of Input Impedance (I_C = 10 mA, V_{CE} = 10 V, f = 100 MHz)	$Re(h_{ie})$	—	30	Ohms

(1) Between 0 and 30 mA.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

2N3244
2N3245

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

2N3227

For Specifications, See 2N2368 Data.

MAXIMUM RATINGS

Rating	Symbol	2N3244	2N3245	Unit
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.175	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N3244 2N3245	$V_{(BR)CEO}$	 40 50	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N3244 2N3245	$V_{(BR)CBO}$	 40 50	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)		I_{BEV}	—	80	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)		I_{CEX}	—	50	nAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)		I_{CBO}	 — —	 0.050 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0) (V_{EB} = 4.0 Vdc, I_C = 0)	 2N3245 2N3244	I_{EBO}	 — —	 30 30	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	 2N3244 2N3245 2N3244 2N3245 2N3244 2N3245	h_{FE}	 60 35 50 30 25 20	 — — 150 90 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	 2N3244 2N3245 2N3244 2N3245 2N3244 2N3245	$V_{CE(sat)}$	 — — — — — —	 0.3 0.35 0.5 0.6 1.0 1.2	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	—	1.1	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			0.75	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3244	f_T	175	—	MHz
	2N3245		150	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	100	pF
SWITCHING CHARACTERISTICS					
Delay Time (I_C = 500 mA, I_{B1} = 50 mA, V_{EB} = 2.0 V, V_{CC} = 30 V)		t_d	—	15	ns
Rise Time (I_C = 500 mA, I_{B1} = 50 mA, V_{EB} = 2.0 V, V_{CC} = 30 V)	2N3244	t_r	—	35	ns
	2N3245		—	40	
Storage Time (I_C = 500 mA, V_{CC} = 30 V, I_{B1} = I_{B2} = 50 mA)	2N3244	t_s	—	140	ns
	2N3245			120	
Fall Time (I_C = 500 mA, V_{CC} = 30 V, I_{B1} = I_{B2} = 50 mA)		t_f	—	45	ns
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)	2N3244	Q_T	—	14	pC
	2N3245		—	12	

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — MINIMUM CURRENT GAIN CHARACTERISTICS

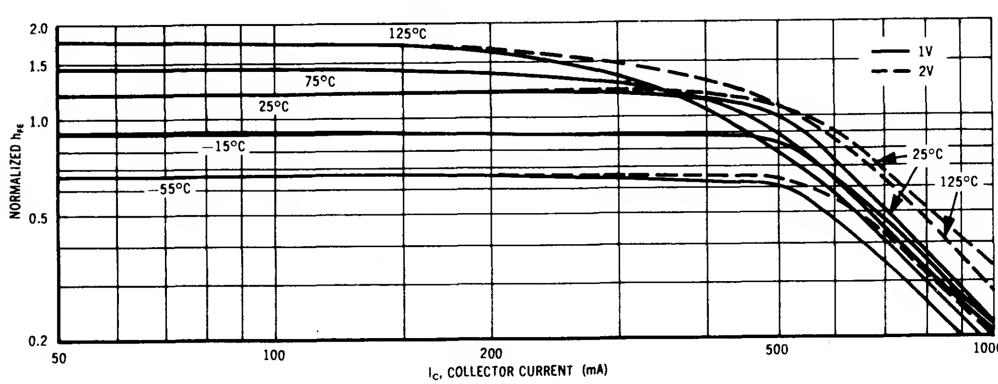
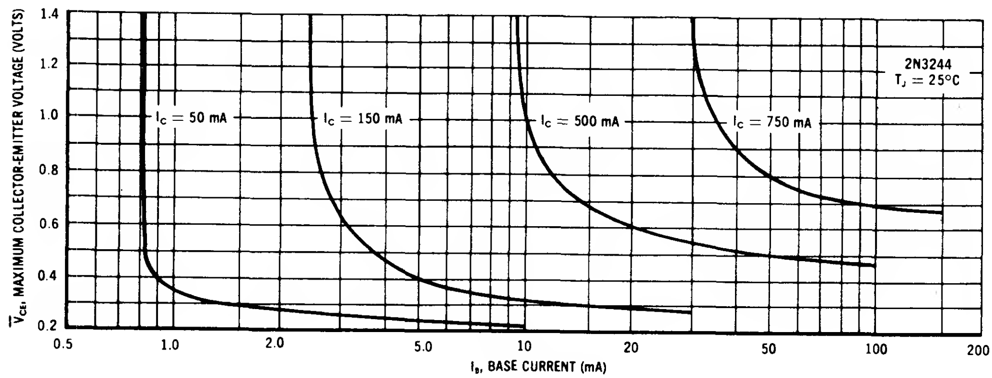


FIGURE 2 — COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS



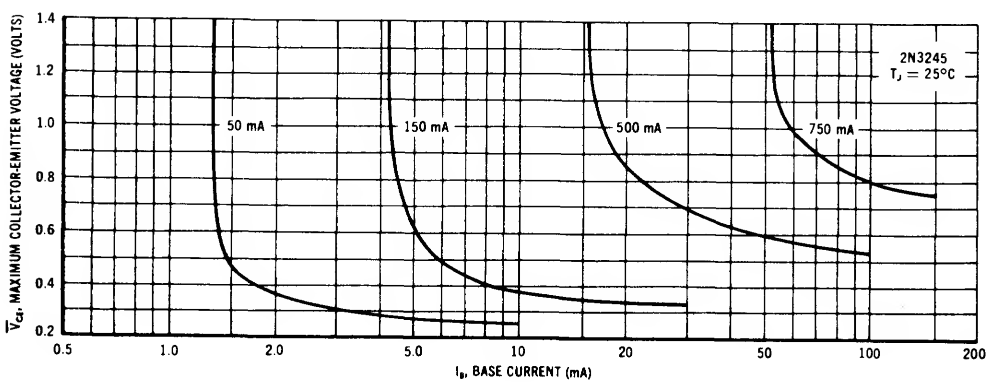


FIGURE 3 — MAXIMUM SATURATION VOLTAGES

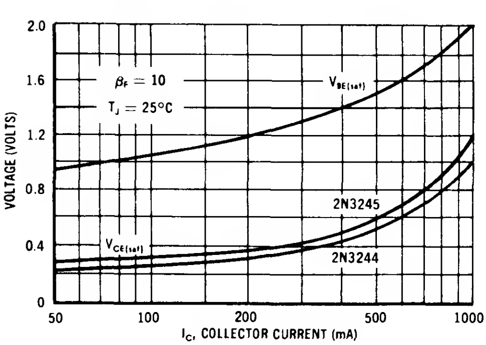


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS

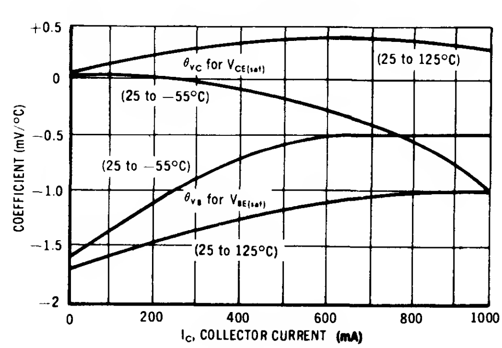


FIGURE 5 — JUNCTION CAPACITANCE

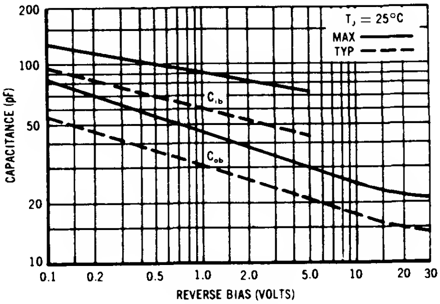


FIGURE 6 — TYPICAL SWITCHING TIMES

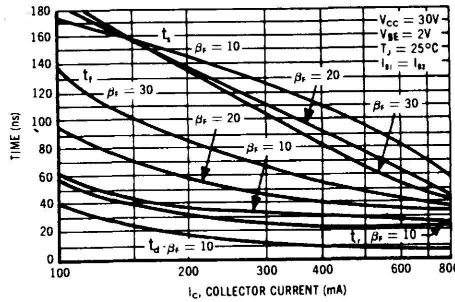


FIGURE 7 — CHARGE DATA

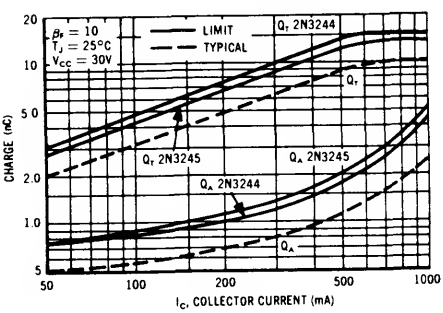


FIGURE 8 — TURN-ON EQUIVALENT TEST CIRCUIT

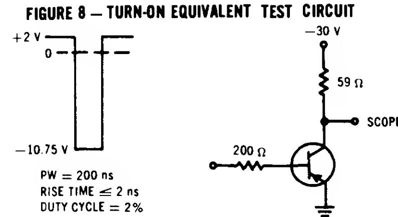


FIGURE 9 — TURN-OFF EQUIVALENT TEST CIRCUIT

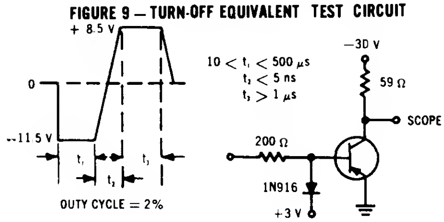


FIGURE 10 — Q_T TEST CIRCUIT

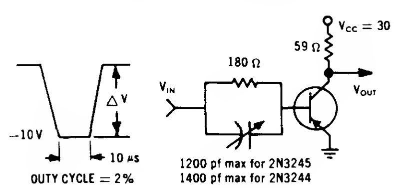
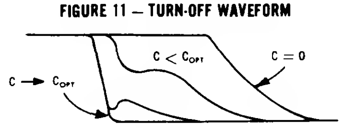


FIGURE 11 — TURN-OFF WAVEFORM



2N3250,A
2N3251,A

2N3250A,2N3251A
JAN, JTX, JTXV AVAILABLE

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR
PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3250 2N3251	2N3250A 2N3251A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.9		Watts mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	mW/°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc)	2N3250, 2N3251 2N3250A, 2N3251A	$V_{(BR)CEO}$	40 60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	2N3250, 2N3251 2N3250A, 2N3251A	$V_{(BR)CBO}$	50 60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 3.0 Vdc)		I_{CEX}	—	20	Adc
Base Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 3.0 Vdc)		I_{BL}	—	50	nAdc
ON CHARACTERISTICS					
DC Forward Current Transfer Radio (1) (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A	h_{FE}	40 80	— —	—
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		45 90	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		15 30	— —	
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	— —	0.25 0.5	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	0.6 —	0.9 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3250, 2N3250A 2N3251, 2N3251A	f_T	250 300	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{CB} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	8.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{ie}	1.0 2.0	6.0 12	kohms
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{re}	— —	10 20	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{oe}	4.0 10	40 60	μmhos
Collector Base Time Constant (I_C = 10 mA, V_{CE} = 20 V)		$r_b'C_C$	—	250	ps
Noise Figure (I_C = 100 μA, V_{CE} = 5.0 V, R_S = 1.0 k Ω, f = 100 Hz)		NF	—	6.0	dB

SWITCHING CHARACTERISTICS

Characteristic			Symbol	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1.0 mA)		t_d	35	ns
Rise Time			t_r	35	ns
Storage Time	(I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc V_{CC} = 3.0 V)	2N3250, 2N3250A 2N3251, 2N3251A	t_s	175 200	ns
Fall Time			t_f	50	ns

(1) Pulse Test: PW = 300 μs, Duty Cycle = 2.0%.

SWITCHING TIME CHARACTERISTICS

FIGURE 1 — DELAY AND RISE TIME

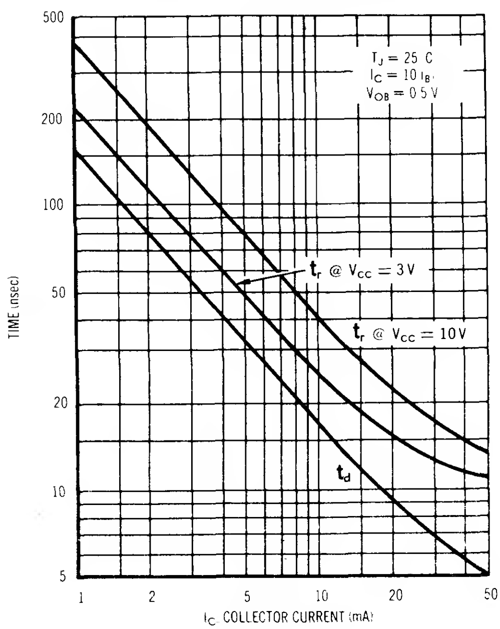
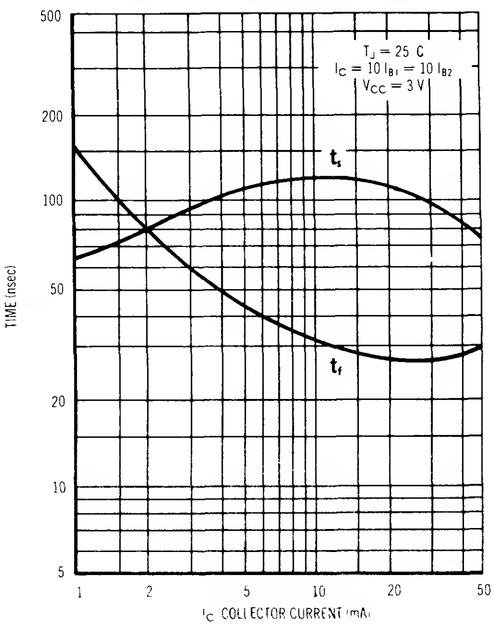


FIGURE 2 — STORAGE AND FALL TIME



4

AUDIO SMALL SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

(V_{CE} = 6 V, T_A = 25°C)

FIGURE 3 — FREQUENCY

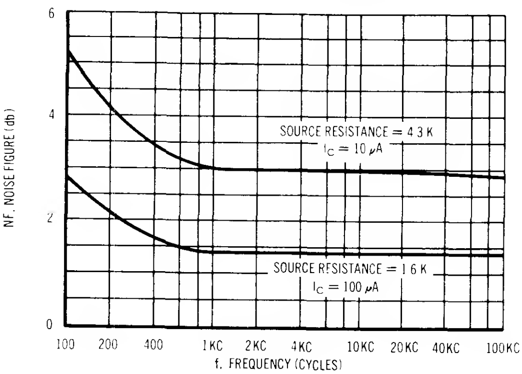
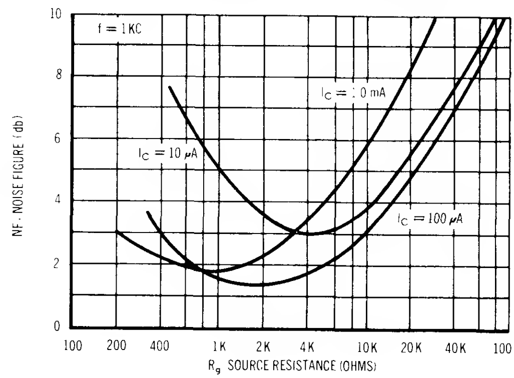


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kc, T_A = 25°C

FIGURE 5 — CURRENT GAIN

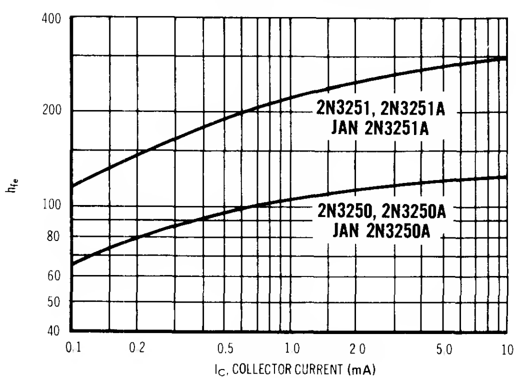


FIGURE 6 — OUTPUT ADMITTANCE

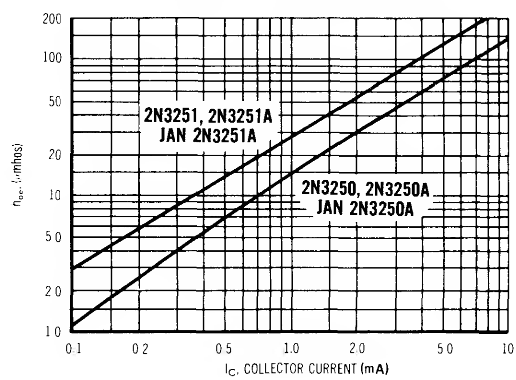


FIGURE 7 — VOLTAGE FEEDBACK RATIO

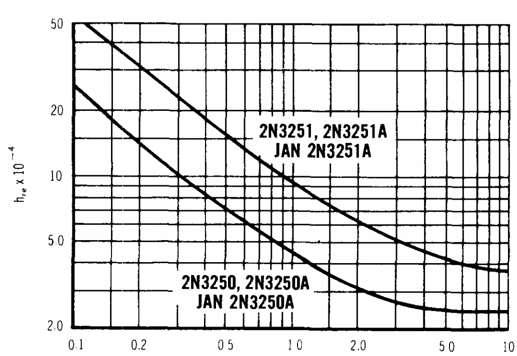


FIGURE 8 — INPUT IMPEDANCE

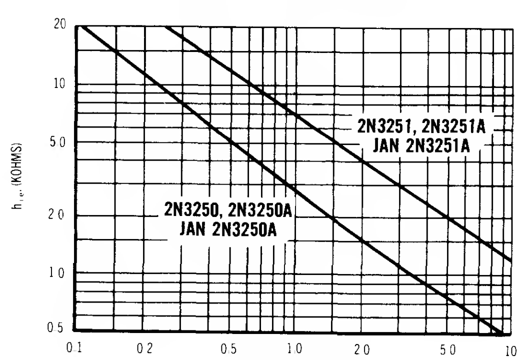


FIGURE 9 — NORMALIZED CURRENT GAIN CHARACTERISTICS

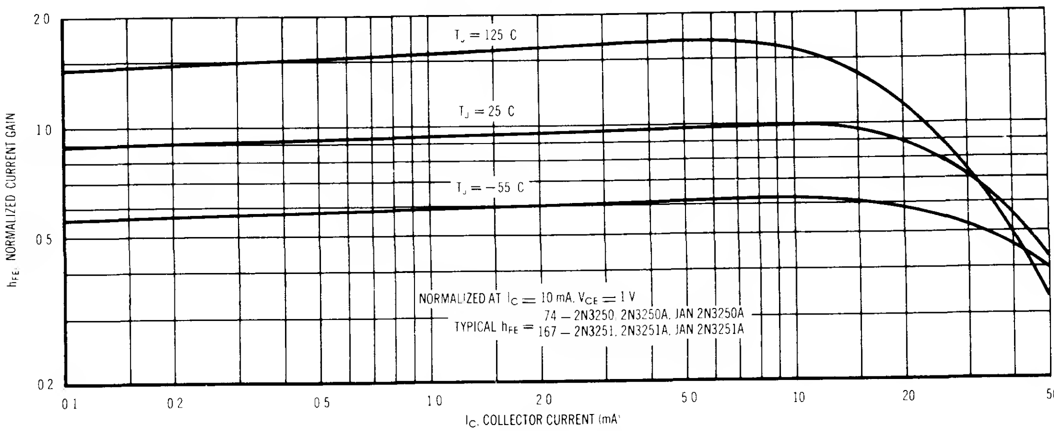
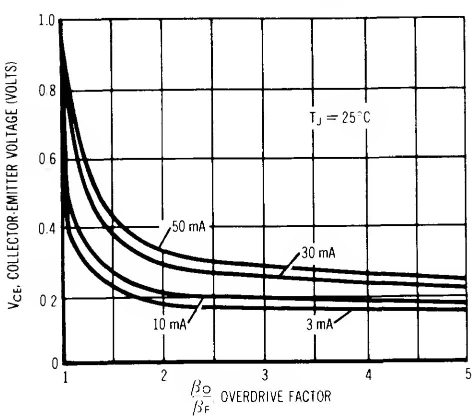


FIGURE 10 — COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3251, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 10 mA.

Observe that at I_C = 10 mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 167 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design).

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\,\text{Volt}}{I_C / I_{BF}} \qquad 2.5 = \frac{167}{10\,\text{mA} / I_{BF}} \qquad I_{BF} \approx 6.68\,\text{mA typ}$$

FIGURE 11 — SATURATION VOLTAGES

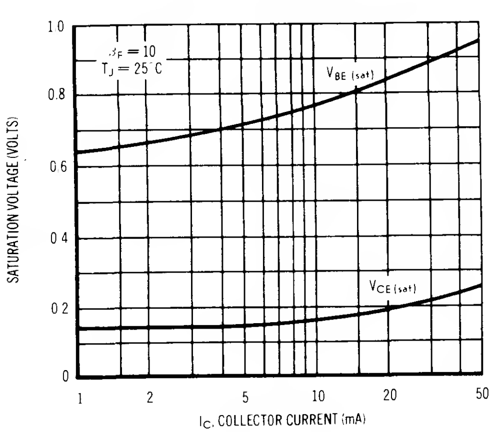


FIGURE 12 — TEMPERATURE COEFFICIENTS

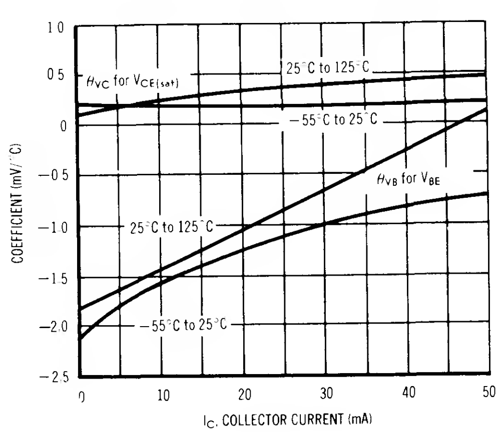


FIGURE 13 — f_T AND $r_b'C_C$ versus I_C

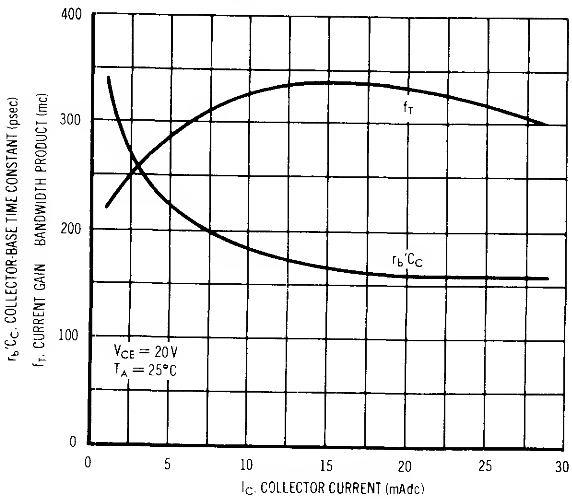


FIGURE 14 — 30 MC EQUIVALENT CIRCUIT

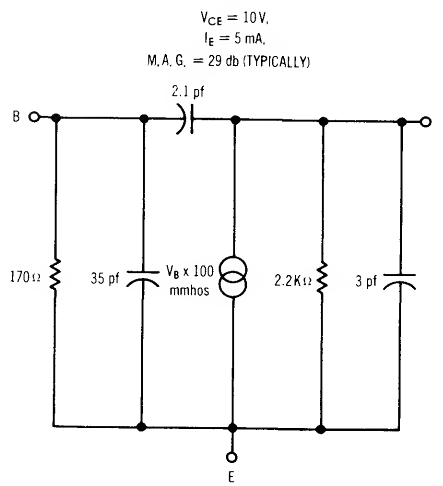


FIGURE 15 — JUNCTION CAPACITANCE

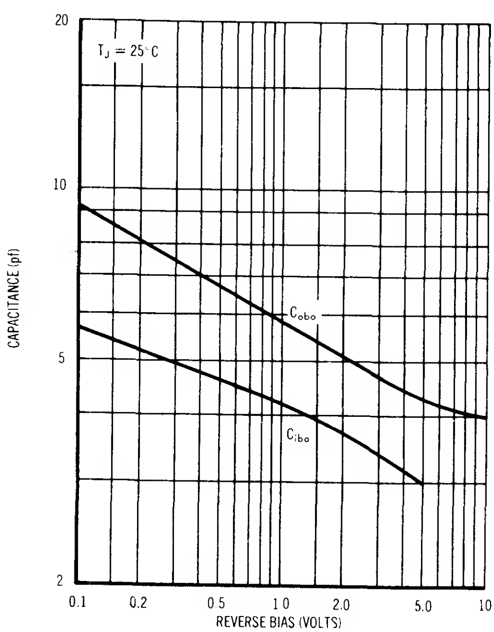
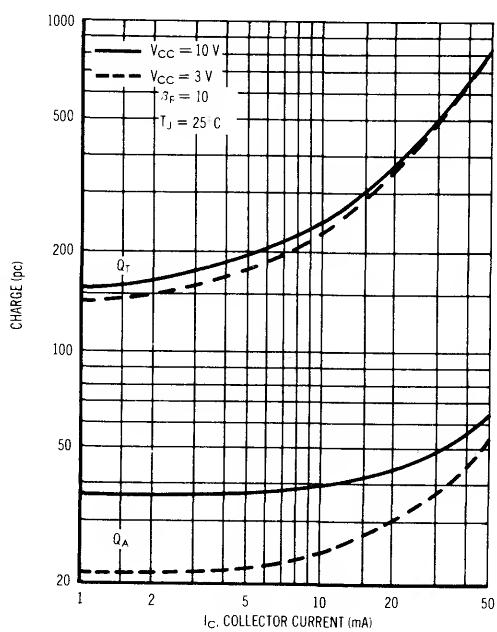


FIGURE 16 — CHARGE DATA



4

2N3252
2N3253
2N3444

GENERAL PURPOSE

NPN SILICON

JAN, JTX AVAILABLE
2N3253, 2N3444
CASE 79, STYLE 1
TO-39 (TO-205AD)

4

MAXIMUM RATINGS

Rating	Symbol	2N3252	2N3253	2N3444	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	50	Vdc
Collector-Base Voltage	V_{CBO}	60	75	80	Vdc
Emitter-Base Voltage	V_{EBO}		5.0		Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		1.0 5.71		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$ $R_{\theta JA}$	35 0.175	°C/W °C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, pulsed, I_B = 0)	2N3252 2N3253 2N3444	$V_{(BR)CEO}$	30 40 50	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3252 2N3253 2N3444	$V_{(BR)CBO}$	60 75 80	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4.0 Vdc) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4.0 Vdc)	2N3252 2N3253, 2N3444	I_{CEX}	— —	0.5 0.5	μAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	2N3252 2N3252 2N3253, 2N3444 2N3253, 2N3444	I_{CBO}	—	0.50 75.0 0.50 75.0	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	0.05	μAdc
Base Cutoff Current (V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4.0 Vdc) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4.0 Vdc)	2N3252 2N3253, 2N3444	I_{BL}	— —	0.50 0.50	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N3252 2N3253 2N3444	h_{FE}	30 25 20	— — —	—
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N3252 2N3253 2N3444		30 25 20	90 75 60	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	2N3252 2N3253 2N3444		25 20 15	— — —	

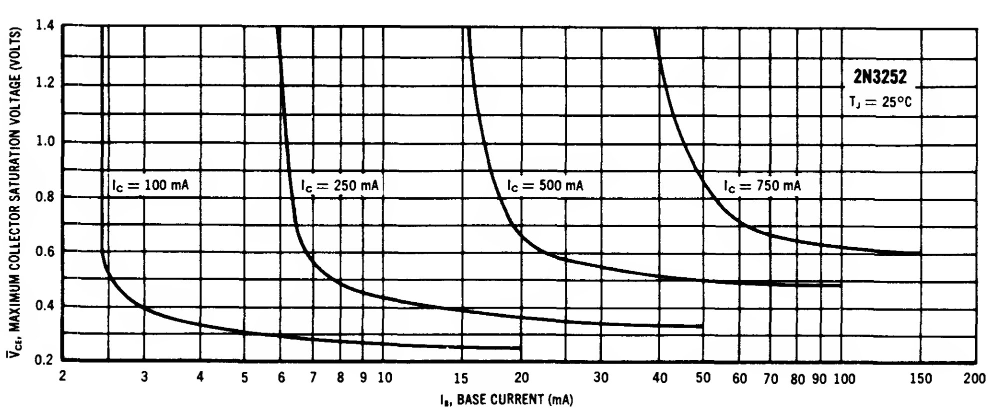
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

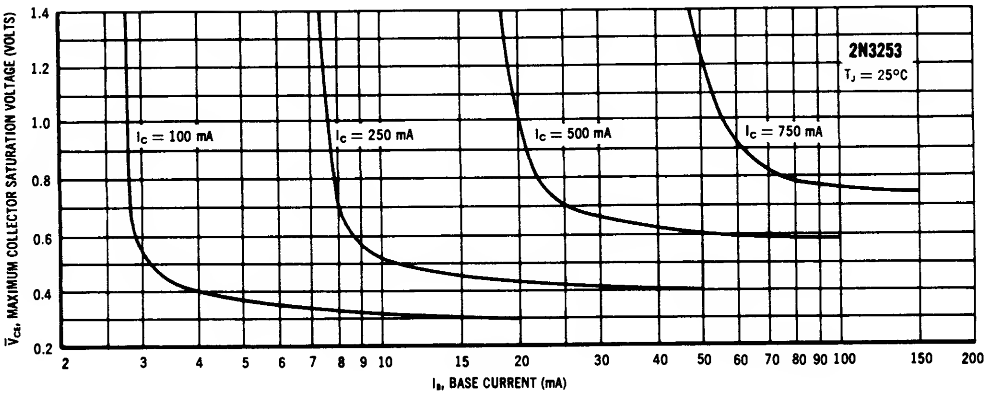
Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3252		—	0.3	
	2N3253, 2N3444		—	0.35	
(I_C = 500 mAdc, I_B = 500 mAdc)	2N3252		—	0.5	
	2N3253, 2N3444		—	0.60	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3252		—	1.0	
	2N3253, 2N3444		—	1.2	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.7	1.3	
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	1.8	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3252		200	—	
	2N3253, 2N3444		175	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	80	pF
SWITCHING CHARACTERISTICS					
Delay Time	I_C = 500 mAdc, I_{B1} = 50 mAdc	t_d	—	15	ns
Rise Time	V_{CC} = 30 V, V_{BE} = 2.0 V 2N3252	t_r	—	30	ns
	2N3253, 2N3444		—	35	
Storage Time	I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc	t_s	—	40	ns
Fall Time	V_{CC} = 30 V	t_f	—	30	ns
Total Control Charge (I_C = 500 mAdc, I_{B1} = 50 mAdc, V_{CC} = 30 V)		Q_T	—	5.0	nC

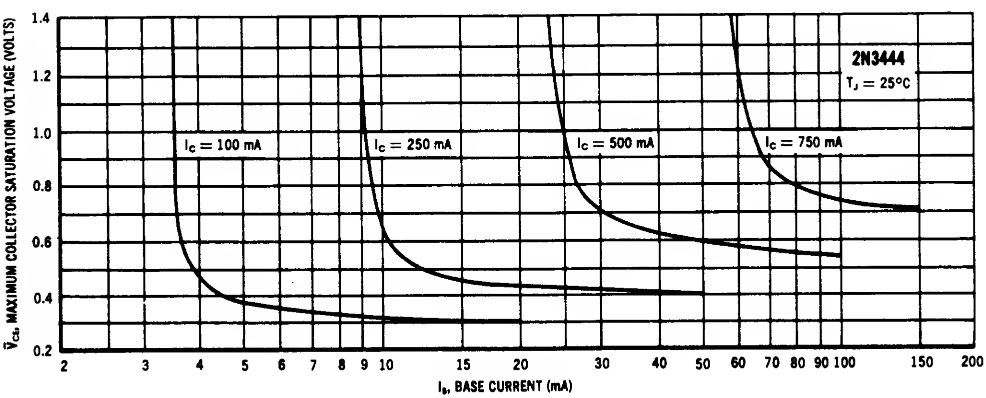
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

4

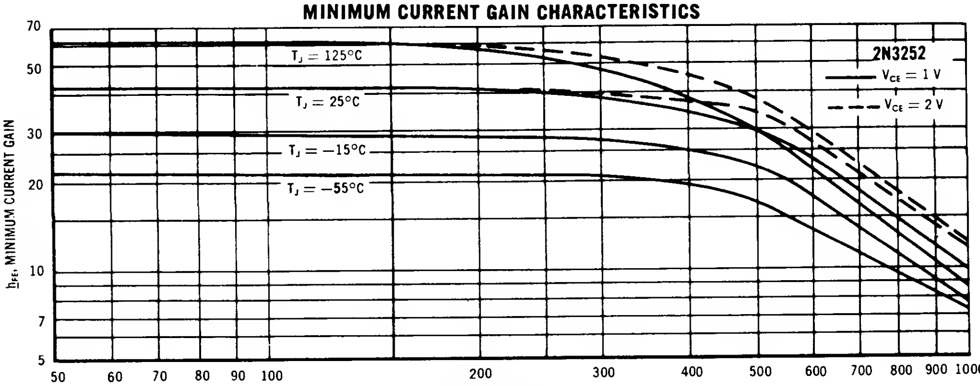
COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

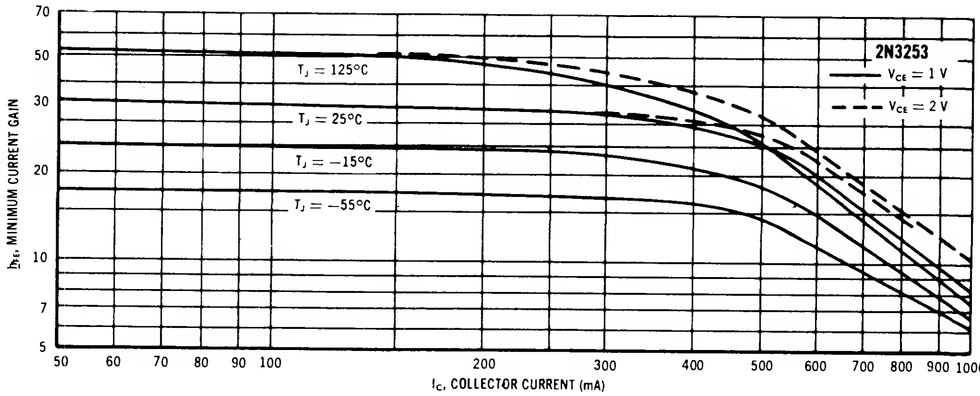


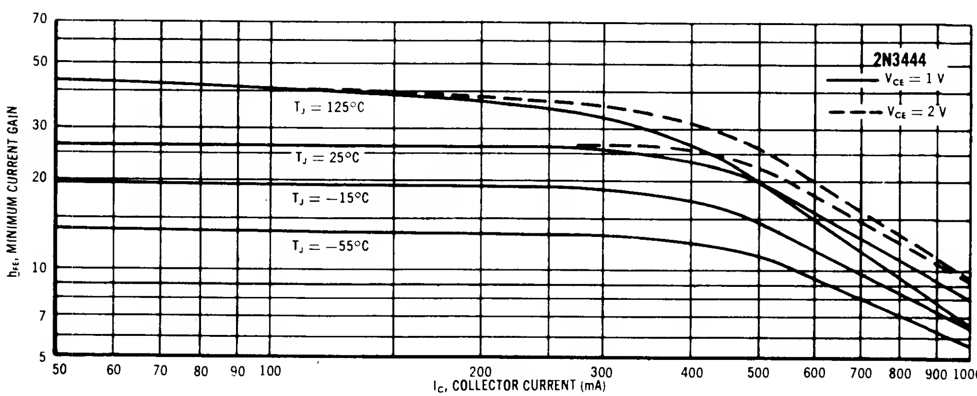




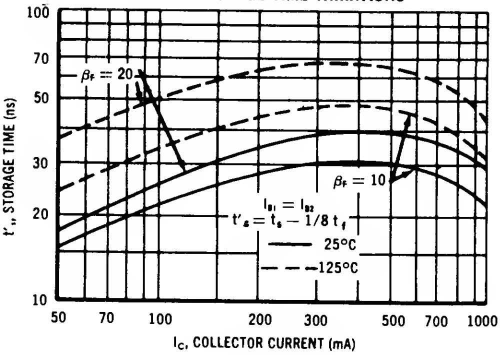
MINIMUM CURRENT GAIN CHARACTERISTICS



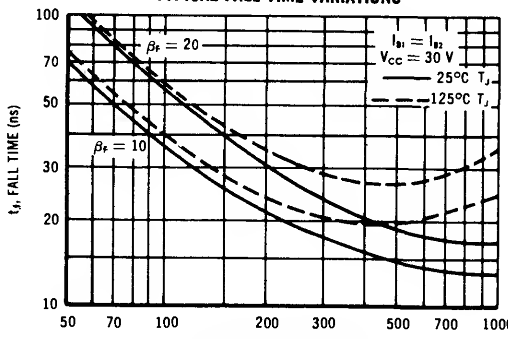




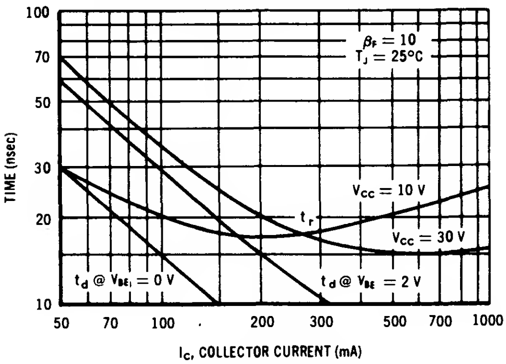
TYPICAL STORAGE TIME VARIATIONS



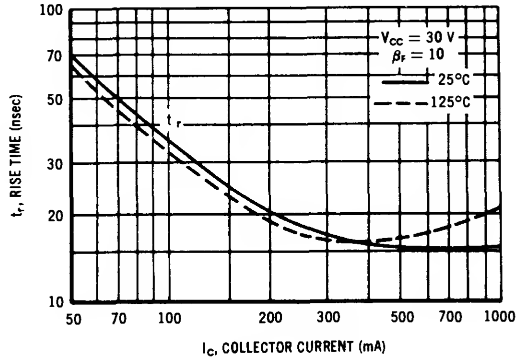
TYPICAL FALL TIME VARIATIONS



TYPICAL TURN-ON TIME VARIATIONS WITH VOLTAGE



TYPICAL RISE TIME VARIATIONS WITH TEMPERATURE



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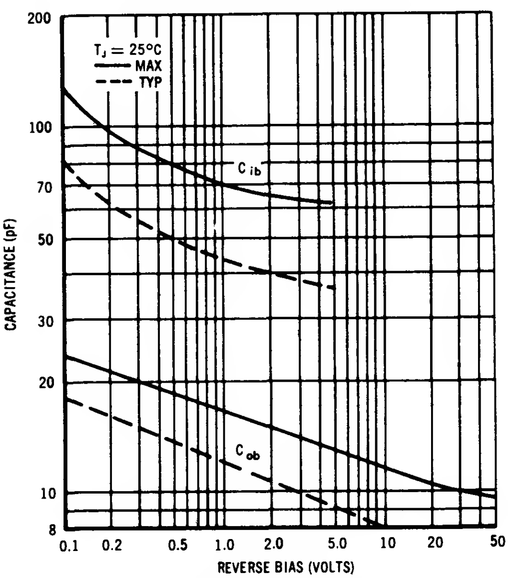
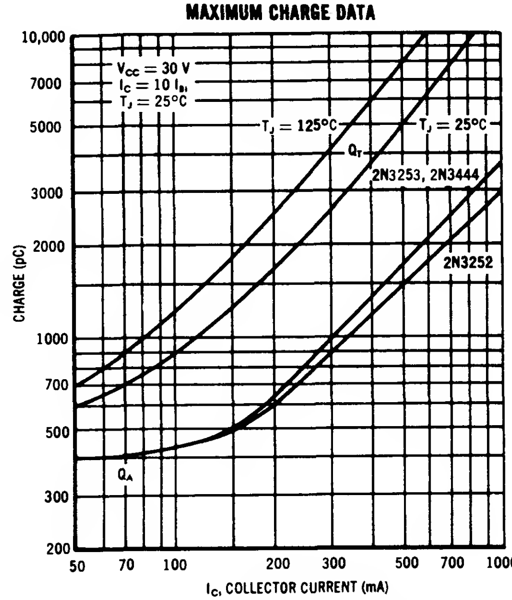
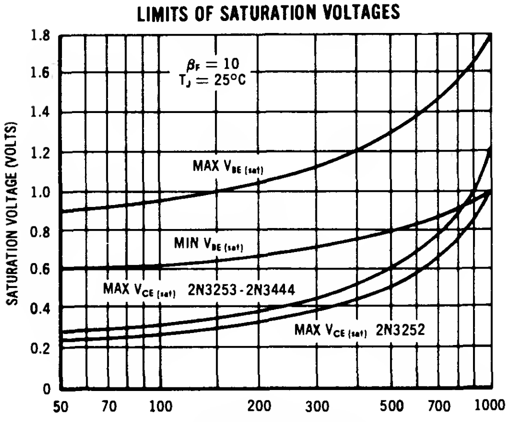
JUNCTION CAPACITANCE VARIATIONS



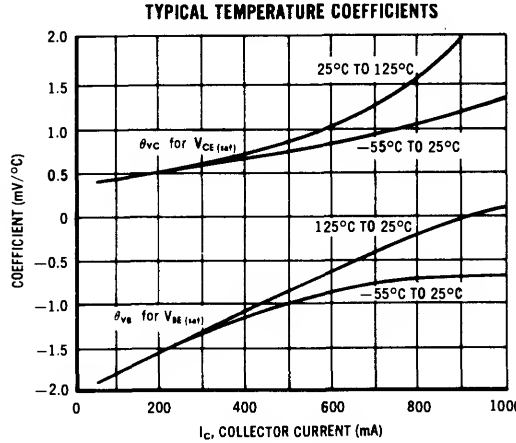
MAXIMUM CHARGE DATA



LIMITS OF SATURATION VOLTAGES



TYPICAL TEMPERATURE COEFFICIENTS



2N3299
2N3300

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

2N3301
2N3302

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N2218 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage (Applicable 0 to 10 mAdc)	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		2N3299 2N3300	**2N3301 2N3302**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.56	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{CEO(sus)}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{BE} = 0) (V_{CE} = 50 Vdc, V_{BE} = 0, T_A = 150°C)		I_{CES}	— —	0.01 10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	10	nAdc
Base Current (V_{CE} = 50 Vdc, V_{BE} = 0)		I_B	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302	h_{FE}	20 35 25 50 35 75 20 50 40 100 20 50	— — — — — — — — 120 300 — —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	— — —	0.22 0.45 0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	— — —	1.1 1.3 1.5	Vdc
Base Emitter Voltage (I_C = 150 mA, V_{CE} = 10 V)		$V_{BE(on)}$	—	1.1 V	Max
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	20	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 25 Vdc, I_C = 300 mAdc, I_{B1} = 30 mAdc)		t_{on}	—	60	ns
Turn-Off Time (V_{CC} = 25 Vdc, I_C = 300 mAdc, I_{B1} = I_{B2} = 30 mAdc)		t_{off}	—	150	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3307
2N3308

CASE 20, STYLE 10
TO-72 (TO-206AF)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3307	2N3308	Unit
Collector-Emitter Voltage	V_{CEO}	35	25	Vdc
Collector-Emitter Voltage	V_{CES}	40	30	Vdc
Collector-Base Voltage	V_{CBO}	40	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	2N3307 2N3308	$V_{(BR)CEO}$	35 25	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	2N3307 2N3308	$V_{(BR)CES}$	40 30	— —	Vdc
Collector-Base Breakdown Voltage(1) (I_C = 10 μAdc, I_E = 0)	2N3307 2N3308	$V_{(BR)CBO}$	40 30	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc) (V_{CB} = 15 Vdc, T = 150°C)	 2N3307	I_{CBO}	— —	0.010 3.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc)	2N3307 2N3308	h_{FE}	40 25	250 250	—
Collector-Emitter Saturation Voltage (I_C = 3.0 mAdc, I_B = 0.6 mAdc)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 3.0 mAdc, I_B = 0.6 mAdc		$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 100 MHz		f_T	300	1200	MHz
Maximum Frequency of Operation (V_{CE} = 10 Vdc, I_C = 2.0 mAdc)		f_{max}	Typical 2000		MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz	2N3307 2N3308	C_{obo}	— —	1.3 1.6	pF
Small-Signal Current Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 1 kHz)	2N3307 2N3308	h_{fe}	40 25	250 250	—
Collector Base Time Constant (V_{CB} = 10 Vdc, I_C = 2.0 mAdc, f = 31.8 MHz)	2N3307 2N3308	$r_{b'}C_c$	2.0 2.0	15 20	ps

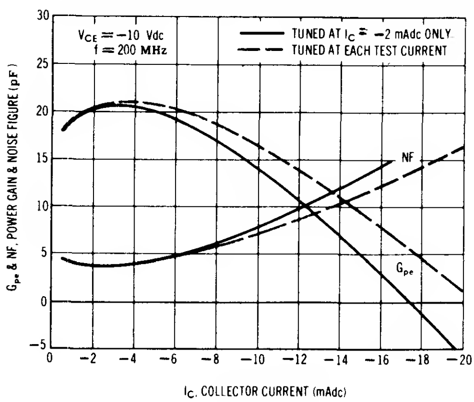
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Noise Figure (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 200 MHz)	2N3307	NF	—	4.5	dB
	2N3308		—	6.0	
SWITCHING CHARACTERISTICS					
Power Gain(2) (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 200 MHz)		G_e	17	—	dB
Power Gain (AGC)(2) (V_{CE} = 5.0 Vdc, I_C = 20 mAdc, f = 200 MHz)	2N3307	G_e	—	0	dB
	2N3308		—	—	

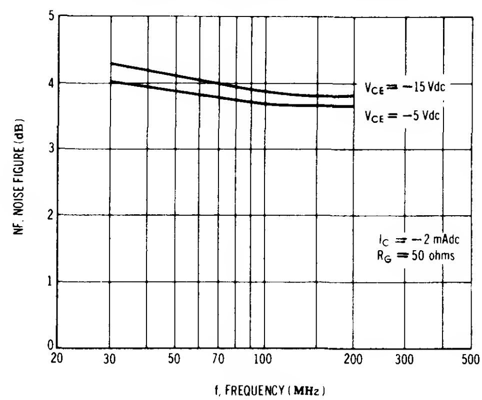
(1) C_{obo} is measured in guarded circuit such that the can capacitance is not included.
(2) AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = −10 Vdc, I_C = −2 mAdc operation.

4

COMMON EMITTER AVERAGE SMALL POWER GAIN & NOISE FIGURE versus COLLECTOR CURRENT



NOISE FIGURE versus FREQUENCY



MAXIMUM RATINGS

Rating	Symbol	PNP 2N5415	PNP 2N5416	NPN 2N3439	NPN 2N3440	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	350	250	Vdc
Collector-Base Voltage	V_{CBO}	200	350	450	300	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	6.0	7.0	7.0	Vdc
Base Current	I_B	0.5				Adc
Collector Current — Continuous	I_C	1.0				Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	— —		1.0 5.7		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 57		5.0 28.6		Watts mW/°C
Total Device Dissipation @ T_A = 50°C Derate above 50°C	P_D	1.0 6.7		— —		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200				°C

2N3439, 2N3440 NPN
2N5415, 2N5416 PNP

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

4

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N5415 2N5416	2N3439 2N3440	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	150	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 50 mAdc, I_B = 0)	2N5415 2N5416 2N3439 2N3440	$V_{CEO(sus)}$	200 300 350 250	— — — —	Vdc
*Collector Cutoff Current (V_{CE} = 300 Vdc, I_B = 0) (V_{CE} = 200 Vdc, I_B = 0)	2N3439 2N3440	I_{CEO}	— —	20 50	μAdc
*Collector Cutoff Current (V_{CE} = 450 Vdc, V_{BE} = 1.5 Vdc) (V_{CE} = 300 Vdc, V_{BE} = 1.5 Vdc)	2N3439 2N3440	I_{CEX}	— —	500 500	μAdc
Collector Cutoff Current (V_{CB} = 175 Vdc, I_E = 0) (V_{CB} = 280 Vdc, I_E = 0) (V_{CB} = 360 Vdc, I_E = 0) (V_{CB} = 250 Vdc, I_E = 0)	2N5415 2N5416 2N3439 2N3440	I_{CBO}	— — — —	50 50 20 20	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0) (V_{EB} = 6.0 Vdc, I_C = 0)	2N5415 2N5416, 2N3439, 2N3440	I_{EBO}	— —	20 20	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc) *(I_C = 20 mAdc, V_{CE} = 10 Vdc) *(I_C = 50 mAdc, V_{CE} = 10 Vdc)	2N3439 2N3439, 2N3440 2N5415 2N5416	h_{FE}	30 40 30 30	— 160 150 120	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)	2N3439, 2N3440	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)	2N3439, 2N3440	$V_{BE(sat)}$	—	1.3	Vdc

*Indicates Data in Addition to JEDEC Requirements.

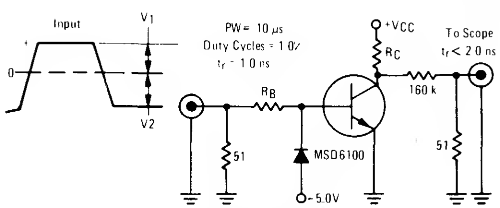
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 50 MHz)	2N3439, 2N3440	f_T	15	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N5415, 2N5416, 2N3439, 2N3440	C_{obo}	— —	15 10	pF
Input Capacitance (V_{EB} = 5.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	75	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10.0 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)	2N5415, 2N5416	h_{fe}	25	—	—
Real Part of Input Impedance (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 MHz)		$Re(h_{ie})$	—	300	Ohms

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
CAUTION: The sustaining voltage *must not* be measured on a curve tracer. (See Fig. 15.)

4

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



NOTE: V_{CC} and R_C adjusted for $V_{CE(off)}$ = 150 V and I_C as desired, R_B chosen for desired I_{B1}, $V_1 \approx 10$ V, $V_2 \approx 8.0$ V

For t_d and t_r, D1 is disconnected and V_2 = 2.0 V

For PNP test circuit, reverse all polarities.

PNP 2N5415, 2N5416 | **NPN 2N3439, 2N3440**

FIGURE 2 — TURN-ON TIME

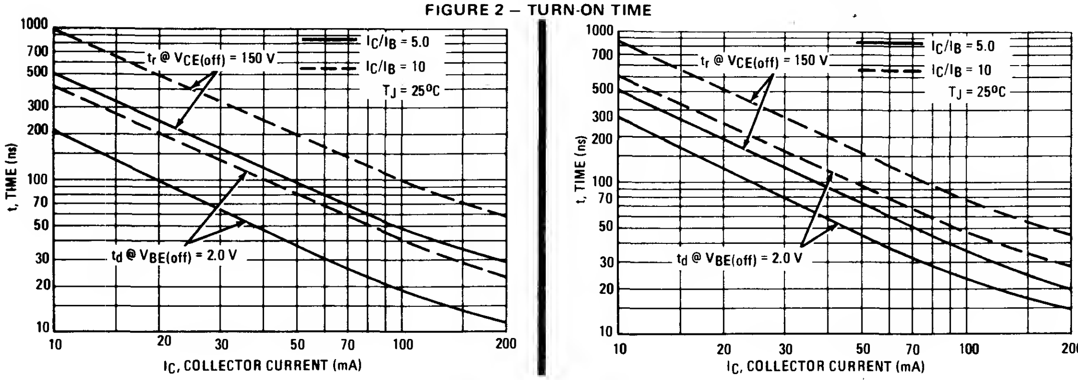


FIGURE 3 — TURN-OFF TIME

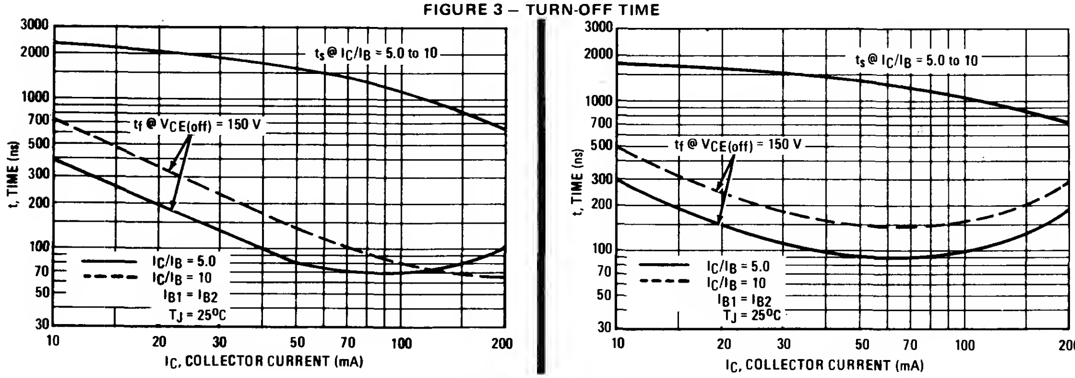


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

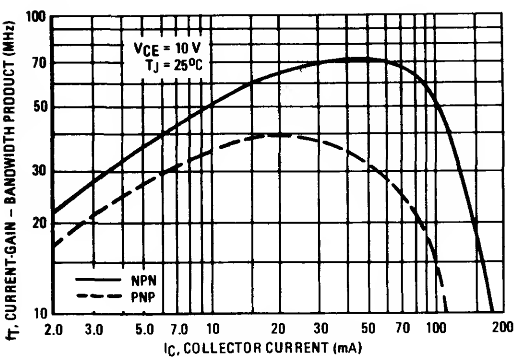


FIGURE 5 – CAPACITANCE

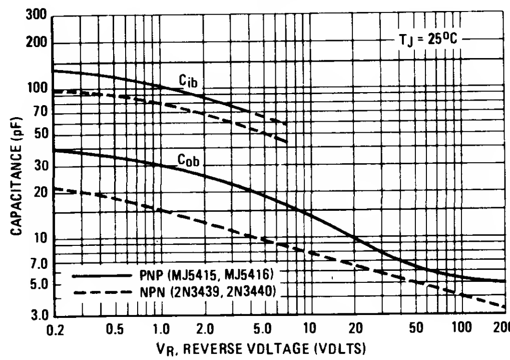


FIGURE 6 – THERMAL RESPONSE

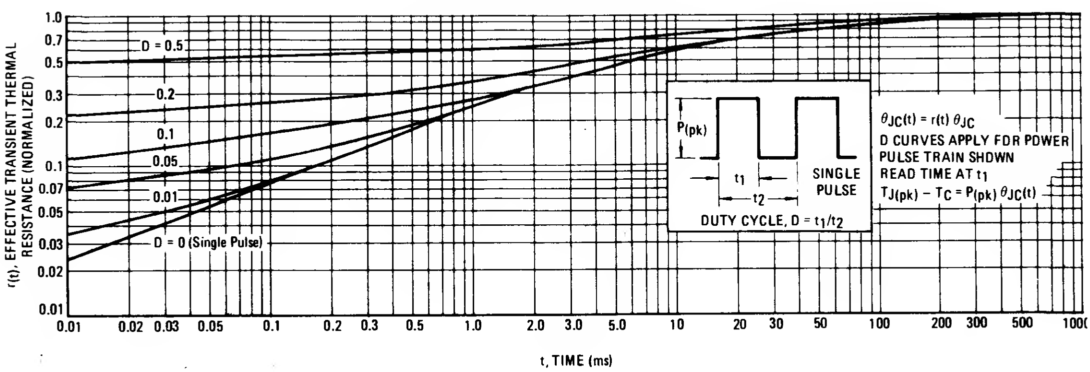
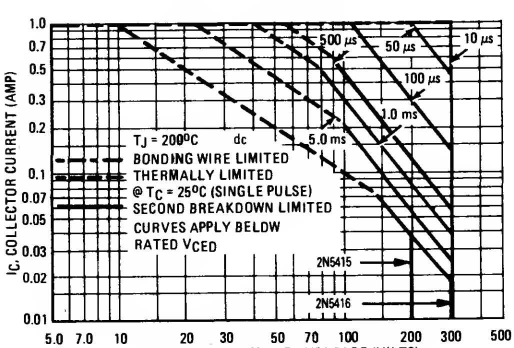


FIGURE 7 – ACTIVE-REGION SAFE OPERATING AREA

PNP — 2N5415, 2N5416



NPN – 2N3439, 2N3440

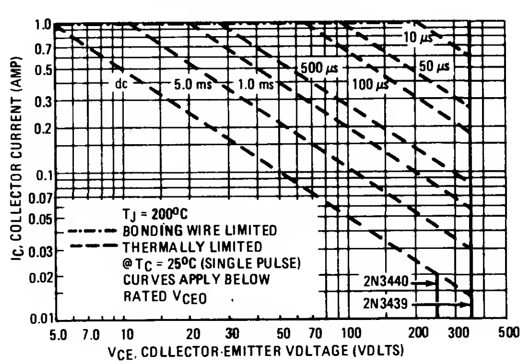
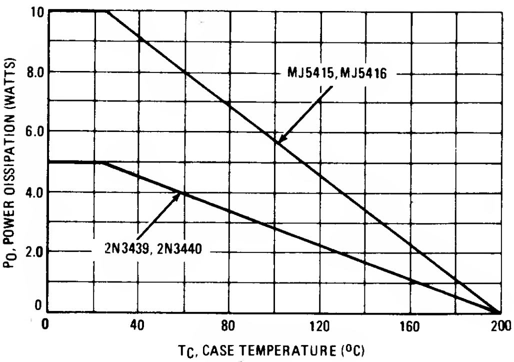


FIGURE 8 – POWER DERATING



There are two limitations on the power handling ability of a transistor, average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on $T_{J(pk)} = 200^\circ C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^\circ C$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

PNP
2N5415, 2N5416

NPN
2N3439 2N3440

FIGURE 9 – DC CURRENT GAIN

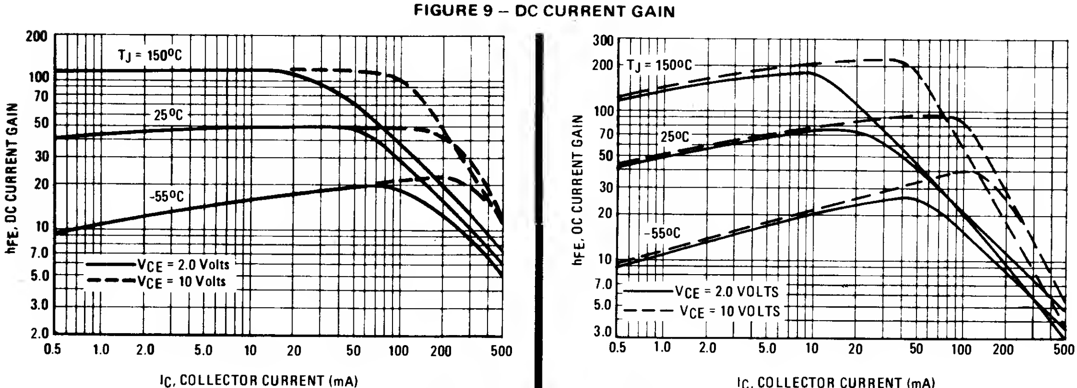


FIGURE 10 – COLLECTOR SATURATION REGION

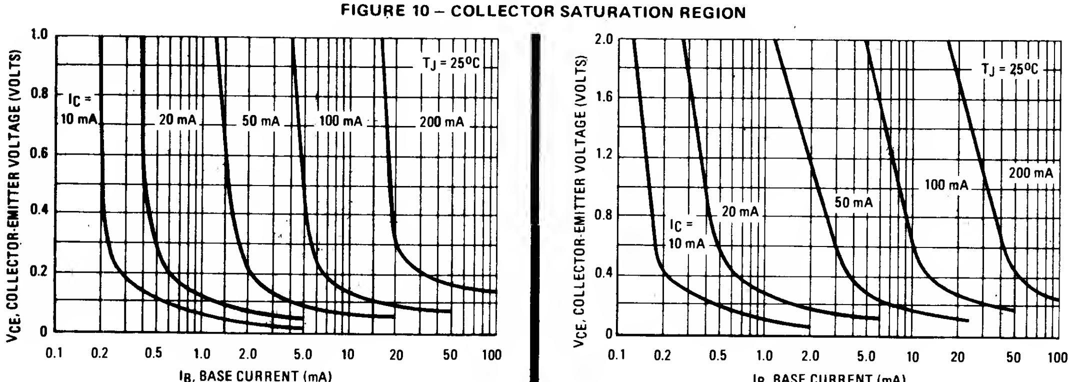


FIGURE 11 – "ON" VOLTAGES

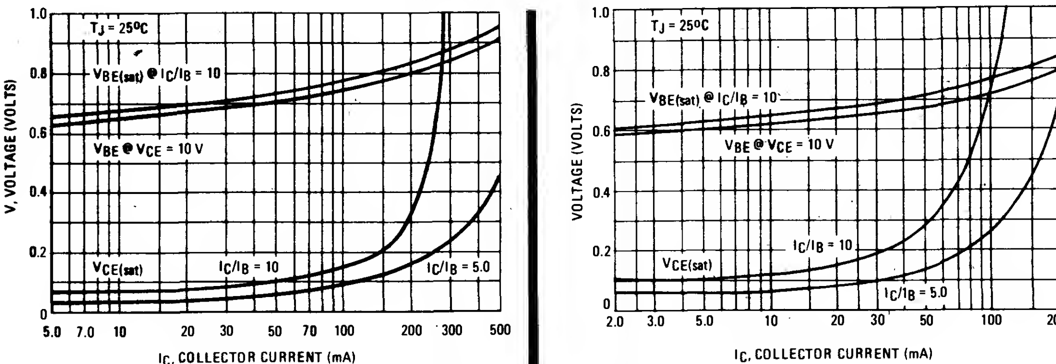


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FIGURE 12 – TEMPERATURE COEFFICIENTS

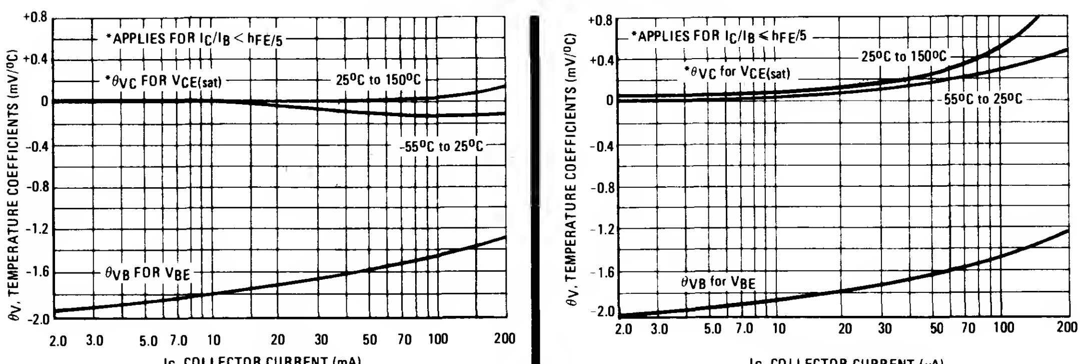
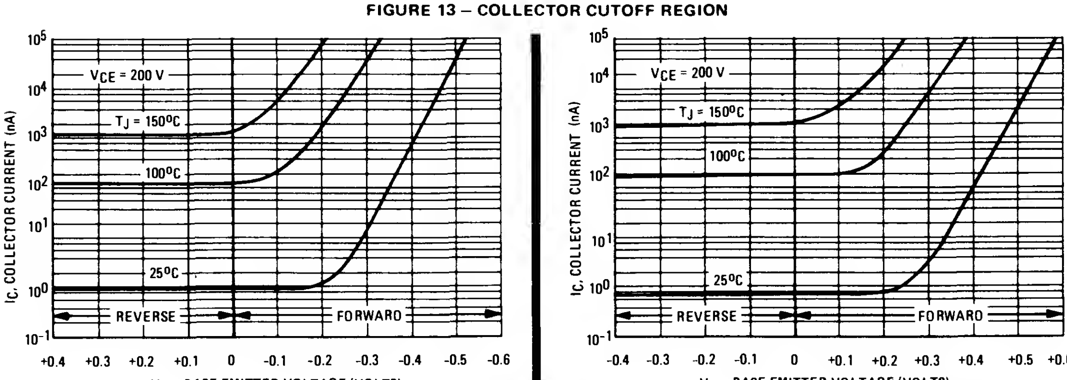
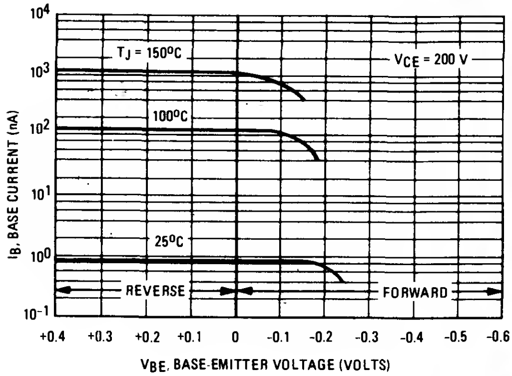


FIGURE 13 – COLLECTOR CUTOFF REGION





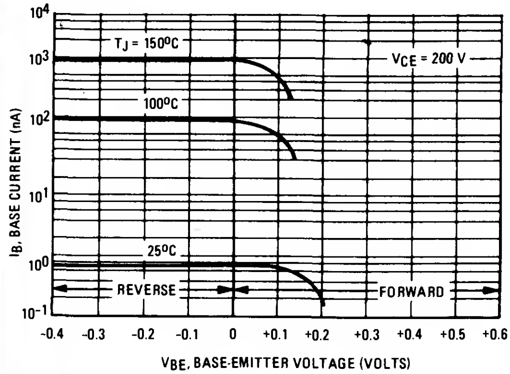
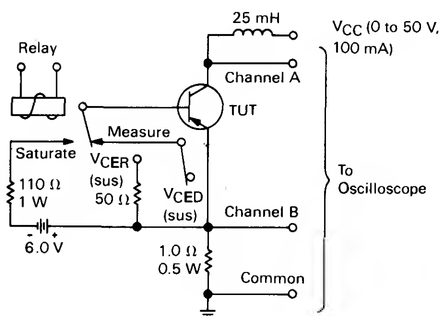


FIGURE 14 – BASE CUTOFF REGION

FIGURE 15 — CIRCUIT USED TO MEASURE SUSTAINING VOLTAGES



4

2N3444

For Specifications, See 2N3252 Data.

2N3467
2N3468

JAN, JTX, JTXV AVAILABLE
CASE 079-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3467	2N3468	Unit
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.175	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

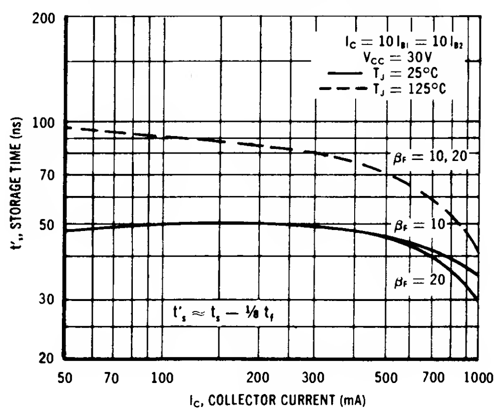
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N3467 2N3468	$V_{(BR)CEO}$	 40 50	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N3467 2N3468	$V_{(BR)CBO}$	 40 50	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = −30 Vdc, V_{BE} = 3.0 Vdc)		I_{BEV}	—	120	nAdc
Collector Cutoff Current (V_{CE} = −30 Vdc, V_{BE} = 3.0 Vdc)		I_{CEX}	—	100	Adc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)		I_{CBO}	 — —	 0.10 15	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	 2N3467 2N3468	h_{FE}	 40 25	 — —	—
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N3467 2N3468		40 25	120 75	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	2N3467 2N3468		40 20	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	 2N3467 2N3468	$V_{CE(sat)}$	 — —	 0.3 0.36	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3467 2N3468		— —	0.5 0.6	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3467 2N3468		— —	1.0 1.2	
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	 — 0.8 —	 1.0 1.2 1.6	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

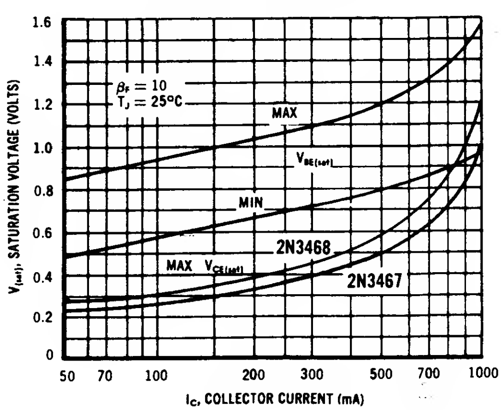
Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3467 2N3468	f_T	175 150	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	100	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = 500 mA, I_{B1} = 50 mA, V_{BE} = 2.0 V, V_{CC} = 30 V)	t_d	—	10	ns
Rise Time		t_r	—	30	ns
Storage Time	(I_C = 500 mA, I_{B1} = I_{B2} = 50 mA, V_{CC} = 30 V)	t_s	—	60	ns
Fall Time		t_f	—	30	ns
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)		Q_T	—	6.0	nC

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

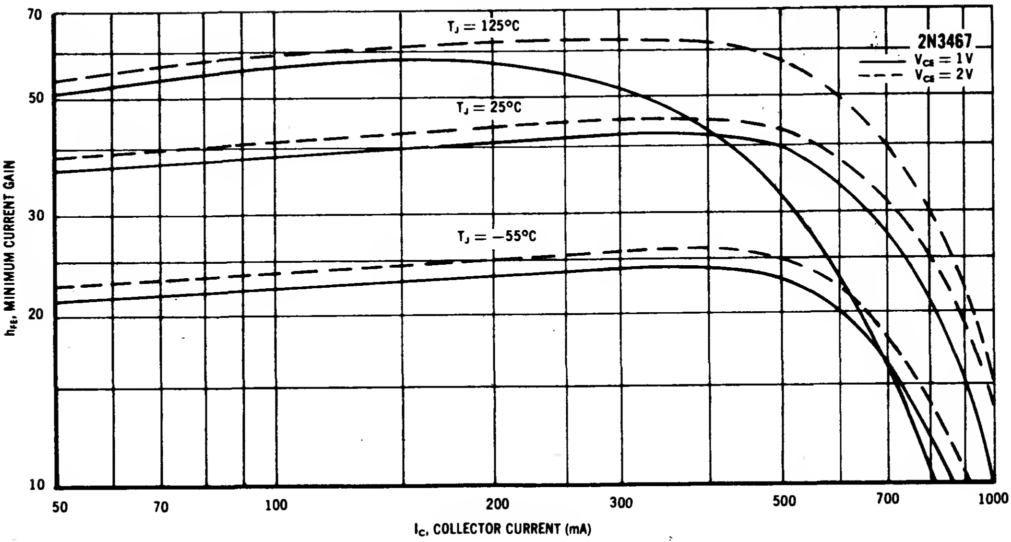
STORAGE TIME VARIATION WITH TEMPERATURE

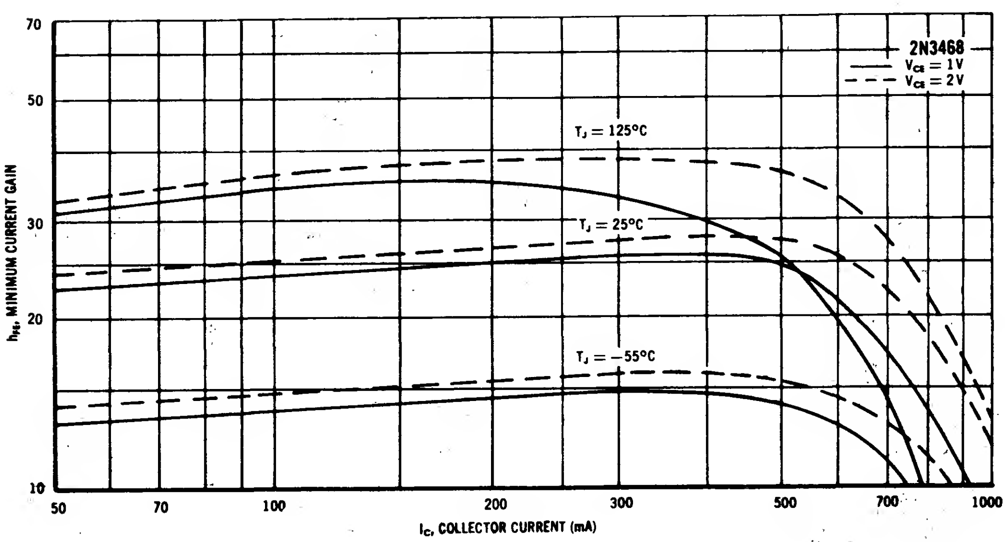


LIMITS OF SATURATION VOLTAGE



MINIMUM CURRENT GAIN CHARACTERISTICS





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4

2N3494
2N3495

CASE 31-03, STYLE 1
TO-39 (TO-205AD)

2N3496
2N3497

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3494 2N3496	2N3495 2N3497	Unit
Collector-Emitter Voltage	V_{CEO}	80	120	Vdc
Collector-Base Voltage	V_{CBO}	80	120	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	100		mAdc
		2N3494 2N3495	**2N3496 2N3497**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 3.43	400 2.28	mW mW/°C
Total Device Dissipation @ T_C = 25°C* Derate above 25°C	P_D	3.0 17.2	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

*Indicates Data in addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	2N3494, 2N3496 2N3495, 2N3497	$V_{(BR)CEO}$	80 120	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3494, 2N3496 2N3495, 2N3497	$V_{(BR)CBO}$	80 120	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0)	 2N3494, 2N3496 2N3495, 2N3497	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	25	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc) (I_C = 100 mAdc, V_{CE} = 10 Vdc)	 2N3494, 2N3496	h_{FE}	 35 40 40 40 35	 — — — — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	2N3494, 2N3496 2N3495, 2N3497	$V_{CE(sat)}$	— —	0.3 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	0.6	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3494, 2N3496 2N3495, 2N3497	f_T	200 150	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N3494, 2N3496 2N3495, 2N3497	C_{obo}	— —	7.0 6.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	30	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	0.1	1.2	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	—	2.0	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	40	300	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	—	300	μmhos
Real Part of Input Impedance (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 300 MHz)	$Re(h_{ie})$	—	30	Ohms
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 30 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	300	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_{off}	—	1000	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

4

FIGURE 1 — TURN-ON TIME TEST CIRCUIT

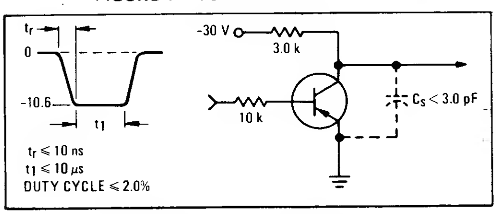

FIGURE 2 — TURN-OFF TIME TEST CIRCUIT

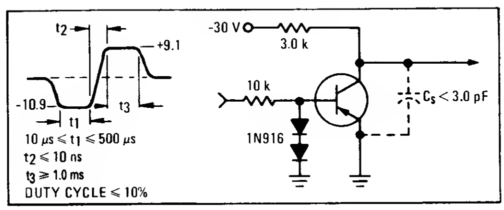

FIGURE 3 — V_{CE} (sat) versus I_C

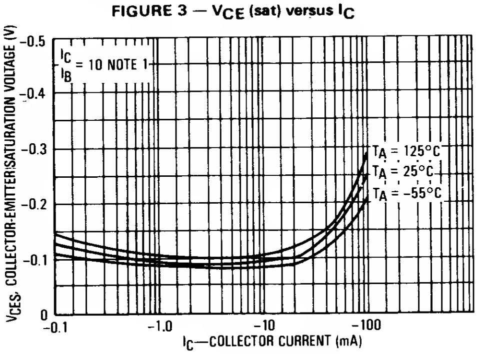

FIGURE 4 — I_{CBO} versus T_A

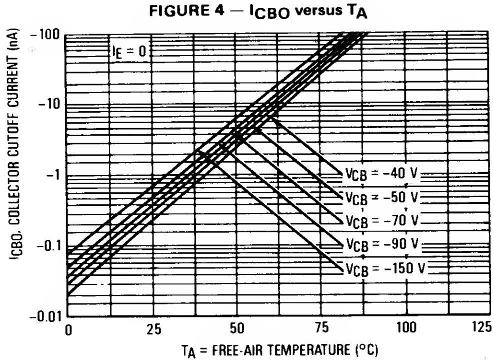

FIGURE 5 — h_{FE} versus I_C

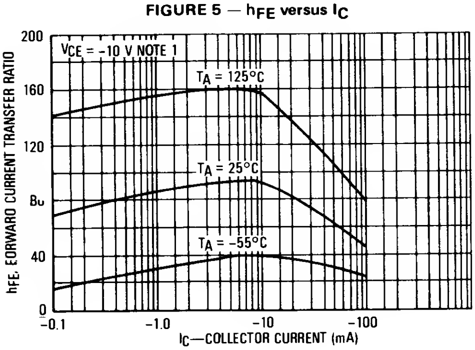

FIGURE 6 — V_{BE} versus I_C

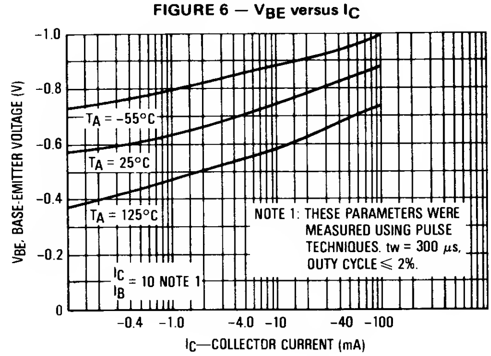

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FIGURE 7 — f_T versus I_C

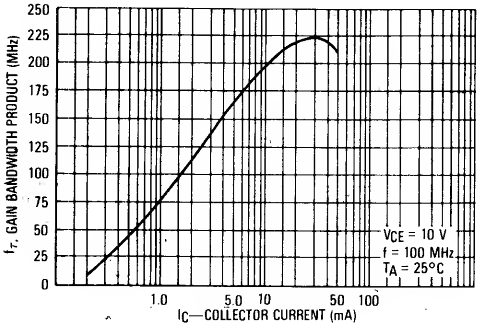


FIGURE 8 — C_{OBO} versus V_{CB}

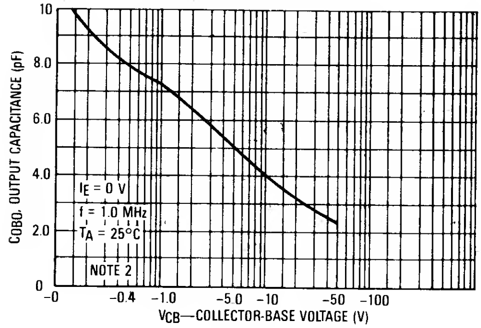
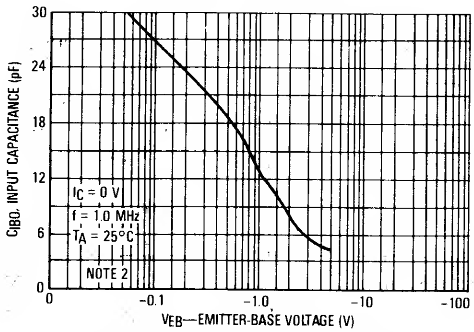


FIGURE 9 — C_{IBO} versus V_{EB}



NOTE 2: CAPACITANCE MEASURE MADE WITH TO-18 PACKAGE.

2N3498 thru 2N3501

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3498 2N3499	2N3500 2N3501	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Collector-Base Voltage	V_{CBO}	100	150	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500	300	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

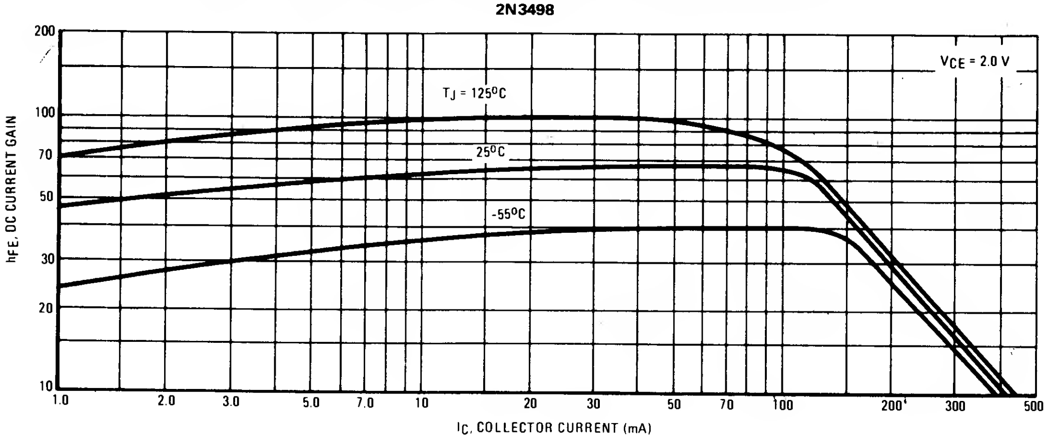
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	2N3498, 2N3499 2N3500, 2N3501	$V_{(BR)CEO}$	100 150	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	2N3498, 2N3499 2N3500, 2N3501	$V_{(BR)CBO}$	100 150	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$) ($V_{CB} = 75$ Vdc, $I_E = 0$) ($V_{CB} = 75$ Vdc, $I_E = 0$, $T_A = 150°C$)	 2N3498, 2N3499 2N3500, 2N3501 	I_{CBO}	 — — — —	 — — — —	 0.050 50 0.050 50	μAdc
Emitter Cutoff Current ($V_{BE(off)} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	25	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc)	2N3498, 2N3500 2N3499, 2N3501		20 35	— —	— —	
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	2N3498, 2N3500 2N3499, 2N3501		25 50	— —	— —	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	2N3498, 2N3500 2N3499, 2N3501		35 75	— —	— —	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	2N3498, 2N3500 2N3499, 2N3501		40 100	— —	120 300	
($I_C = 300$ mAdc, $V_{CE} = 10$ Vdc)	2N3500 2N3501		15 20	— —	— —	
($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	2N3498 2N3499		15 20	— —	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)	 All Types All Types 2N3500, 2N3501 2N3498, 2N3499	$V_{CE(sat)}$	 — — — —	 — — — —	 0.2 0.25 0.4 0.6	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types		—	—	0.8	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	All Types		—	—	0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501		—	—	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3498, 2N3499		—	—	1.4	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 MHz)		f_T	150	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N3498, 2N3499 2N3500, 2N3501	C_{obo}	— —	— —	10 8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	—	80	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{ie}	0.2 0.25	— —	1.0 1.25	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{re}	— —	— —	2.5 4.0	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{fe}	50 75	— —	300 375	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{oe}	— —	— —	100 200	μmhos
SWITCHING CHARACTERISTICS						
Delay Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc)		t_d	—	20	—	ns
Rise Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc)		t_r	—	35	—	ns
Storage Time (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, V_{CC} = 100 Vdc)		t_s	—	800	—	ns
Fall Time (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, V_{CC} = 100 Vdc)		t_f	—	80	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 1 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3498



2N3499

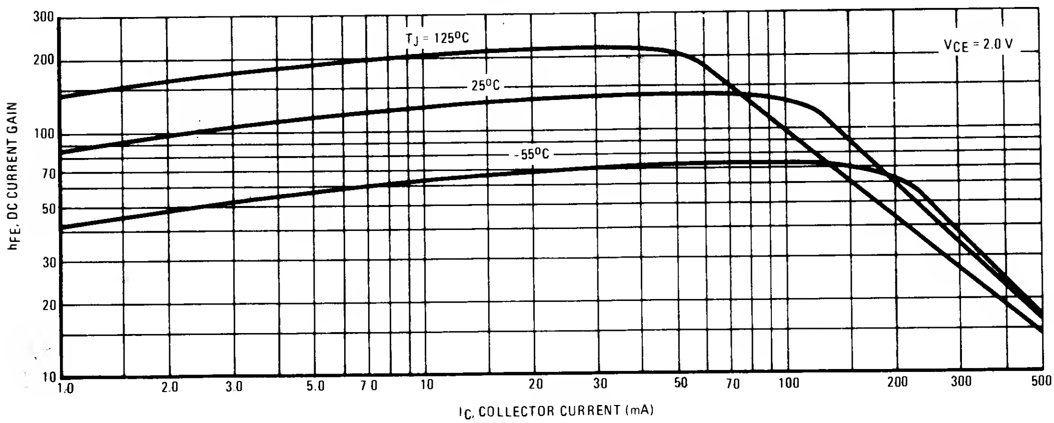


FIGURE 2 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

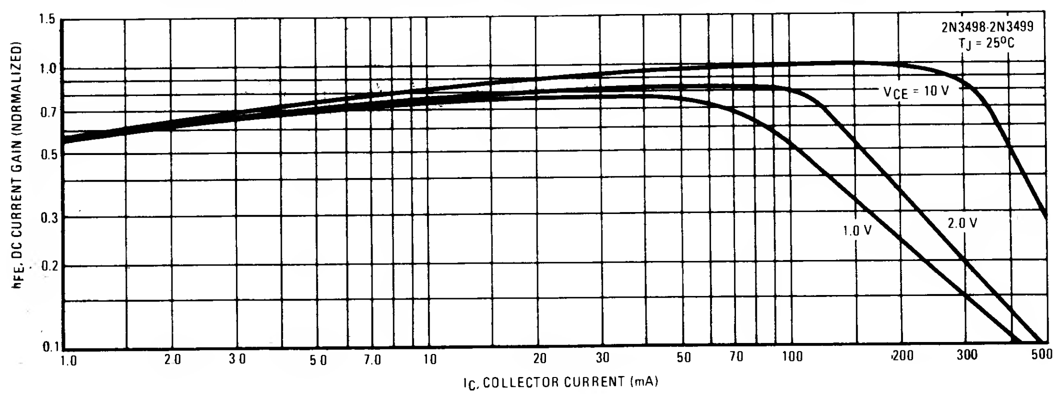
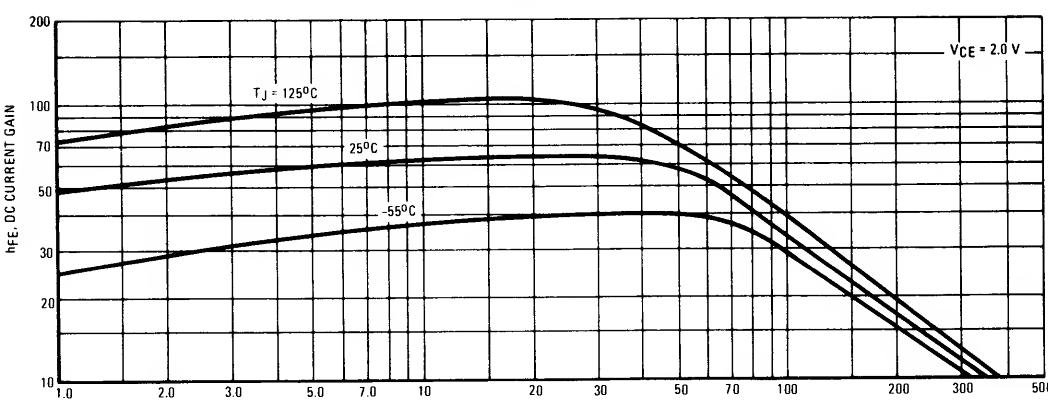


FIGURE 3 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

2N3500



2N3501

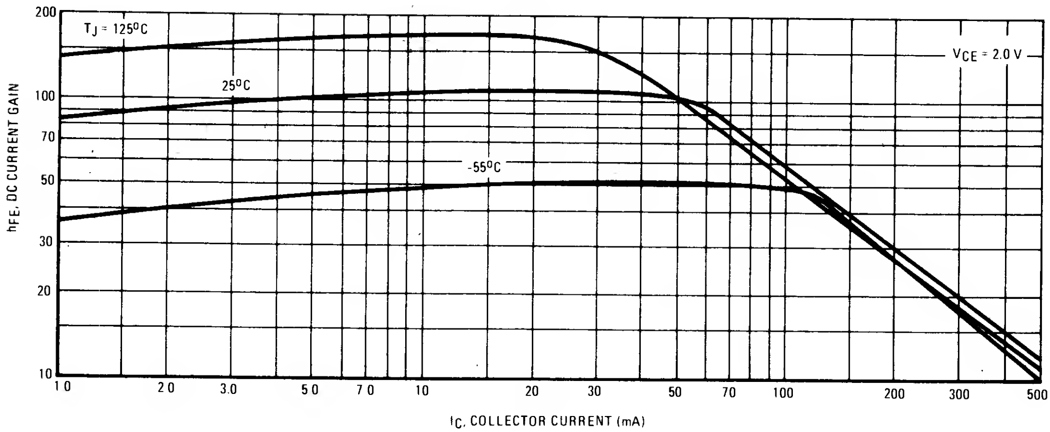


FIGURE 4 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

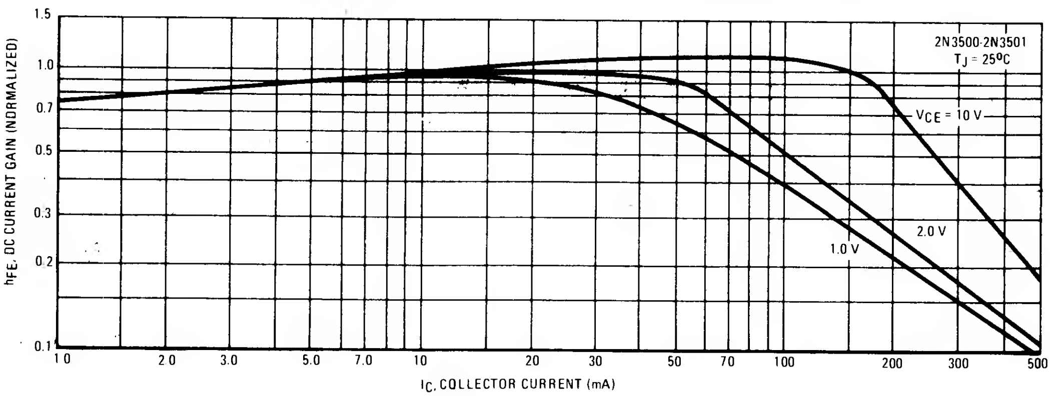


FIGURE 5 – "ON" VOLTAGES

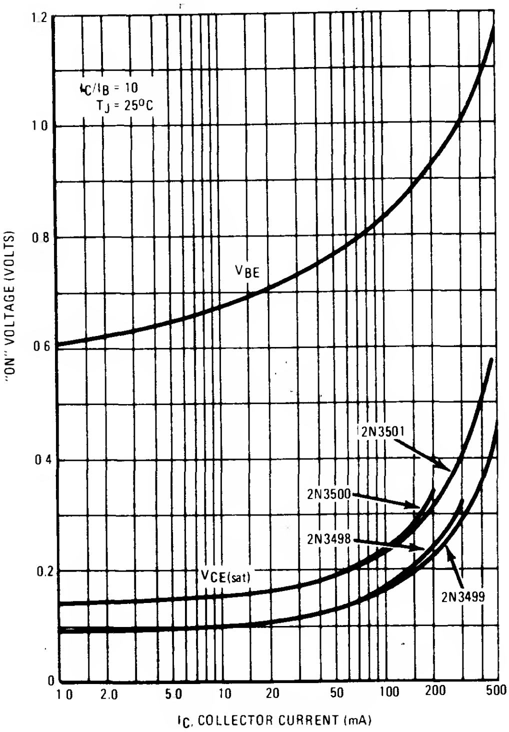


FIGURE 6 – TEMPERATURE COEFFICIENTS

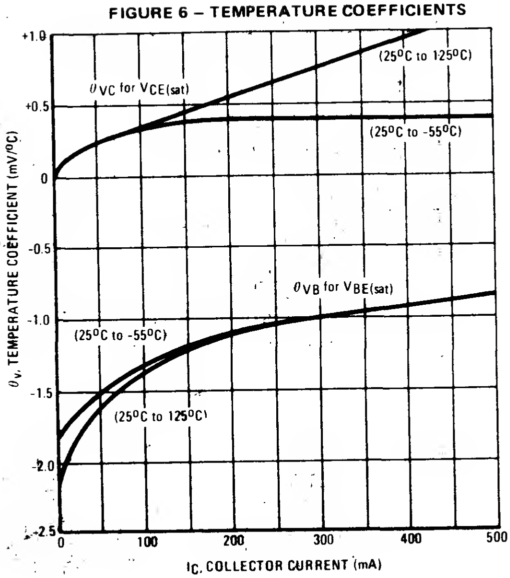
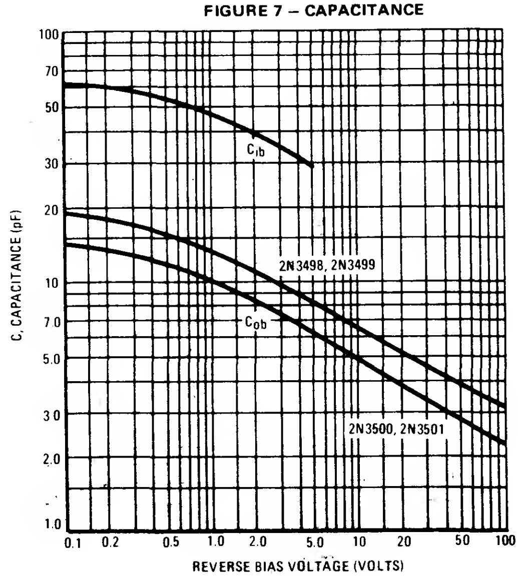


FIGURE 7 – CAPACITANCE



AUDIO SMALL-SIGNAL h PARAMETER CHARACTERISTICS

(V_{CE} = 10 Vdc, T_A = 25°C, f = 1.0 kHz)

FIGURE 8 – CURRENT GAIN

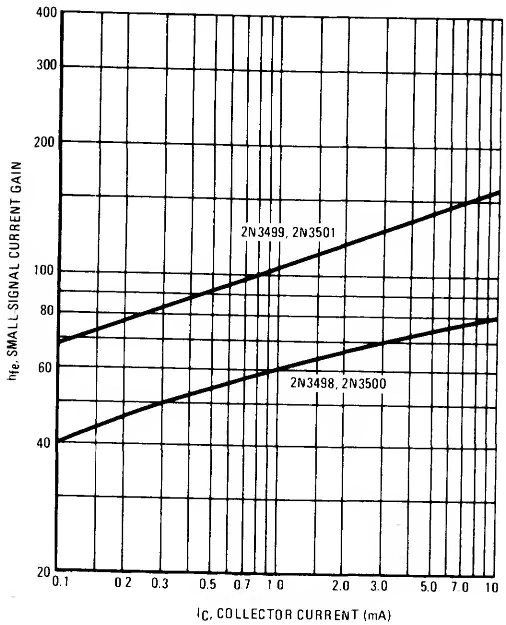


FIGURE 9 – OUTPUT IMPEDANCE

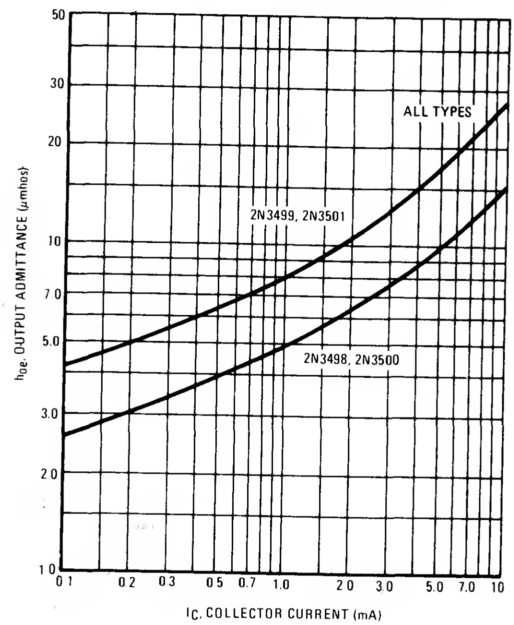


FIGURE 10 – INPUT IMPEDANCE

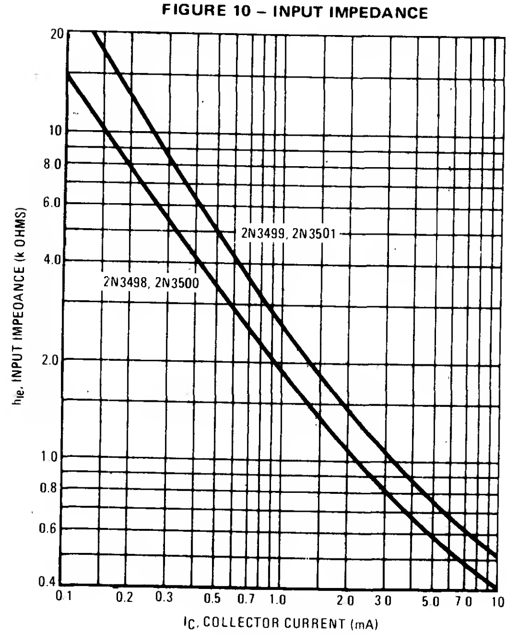
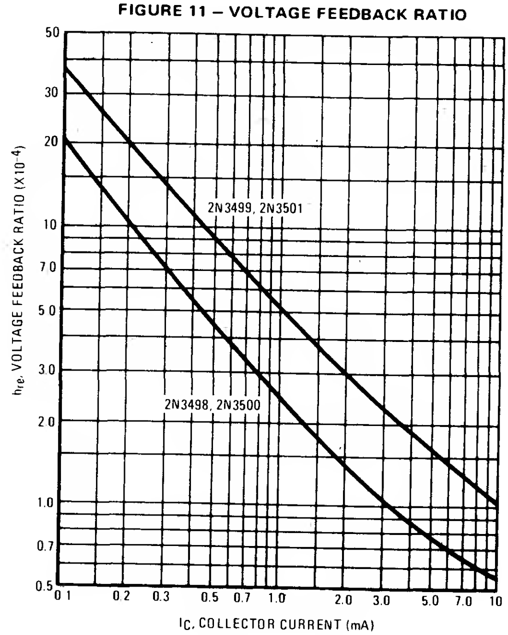


FIGURE 11 – VOLTAGE FEEDBACK RATIO



2N3506
2N3507

JAN, JTX, JTXV AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3506	2N3507	Unit
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	3.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.175	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

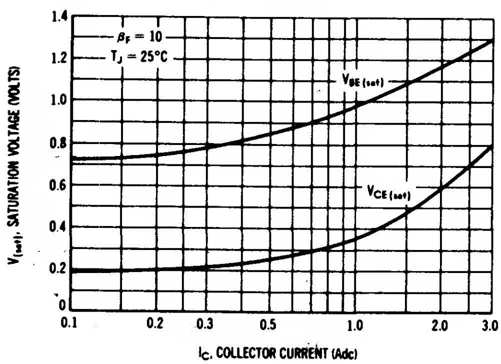
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, pulsed, I_B = 0)	2N3506 2N3507	$V_{(BR)CEO}$	40 50	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N3506 2N3507	$V_{(BR)CBO}$	60 80	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4.0 Vdc) (V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4.0 Vdc, T_A = 100°C) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4.0 Vdc) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4.0 Vdc, T_A = 100°C)	2N3506 2N3507	I_{CEX}	— — — —	1.0 150 1.0 150	μAdc
Base Cutoff Current (V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4.0 Vdc) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4.0 Vdc)	2N3506 2N3507	I_{BL}	— —	1.0 1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.5 Adc, V_{CE} = 2.0 Vdc) (I_C = 2.5 Adc, V_{CE} = 3.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)	2N3506 2N3507 2N3506 2N3507 2N3506 2N3507 2N3506 2N3507	h_{FE}	50 35 40 30 30 25 25 20	— — 200 150 — — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.5 Adc, I_B = 150 mAdc) (I_C = 2.5 Adc, I_B = 250 mAdc)		$V_{CE(sat)}$	— — —	0.5 1.0 1.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.5 Adc, I_B = 150 mAdc) (I_C = 2.5 Adc, I_B = 250 mAdc)		$V_{BE(sat)}$	— 0.9 —	1.0 1.4 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)		f_T	60	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	40	pF
Input Capacitance (V_{BE} = 3 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	300	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

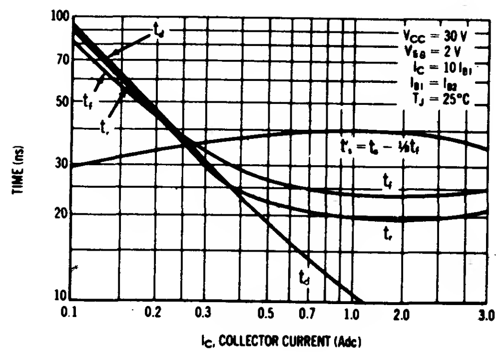
Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	I_C = 1.5 Adc, I_{B1} = 150 mAdc	t_d	—	15	ns
Rise Time	V_{CC} = 30 V, V_{EB} = 0 V	t_r	—	30	ns
Storage Time	I_C = 1.5 Adc, I_{B1} = I_{B2} = 150 mAdc	t_s	—	55	ns
Fall Time	V_{CC} = 30 V	t_f	—	35	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

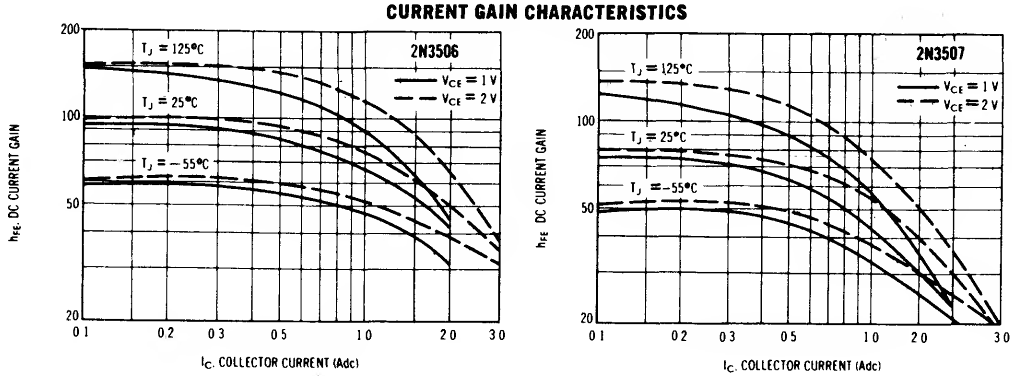
SATURATION VOLTAGES



SWITCHING TIMES



CURRENT GAIN CHARACTERISTICS



2N3508
2N3509

CASE 26, STYLE 1
TO-46 (TO-206AB)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current (10 μs pulse) (Peak)	I_C	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.40 2.29	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 11.43	Watts mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.0875	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.438	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_B = 0)		$V_{(BR)CBO}$	40	—	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc)		$V_{(BR)CEO}$	20	—	Vdc
Collector-Emitter Voltage (I_C = 10 μAdc, I_B = 0)		$V_{(BR)CES}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		I_{CEX}	—	0.2	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc) (V_{CB} = 20 Vdc, T_A = 150°C)	 Both Types 2N3508 2N3509	I_{CBO}	 — — —	 0.2 30 50	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		I_{BL}	—	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	 2N3508 2N3509 2N3508 2N3509 2N3508 2N3509	h_{FE}	 40 100 20 40 20 30	 120 300 — — — —	—
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.45	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$	 0.70 0.8	 0.85 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	4.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		h_{fe}	5.0	—	—
SWITCHING CHARACTERISTICS					
Storage Time (I_C = I_{B1} = I_{B2} = 10 mA)		$t_s(\tau_s)$	—	13	ns
Turn-On Time (I_C = 10 mA, I_{B1} = 3.0 mA, V_{CC} = 3.0 V, V_{OB} = 1.5 V)		t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mA, I_{B1} = 3.0 mA, I_{B2} = 1.5 mA, V_{CC} = 3.0 V)		t_{off}	—	18	ns
Total Control Charge (I_C = 10 mA, I_B = 1.0 mA, V_{CC} = 3.0 V)		Q_T	—	50	pC
Delay Time	V_{CC} = 10 V, V_{EB} = 2.0 V, I_C = 100 mA, I_{B1} = 10 mA	t_d	—	5.0	ns
Rise Time		t_r	—	18	ns
Storage Time	V_{CC} = 10 V I_C = 100 mA, I_{B1} = I_{B2} = 10 mA	t_s	—	13	ns
Fall Time		t_f	—	15	ns

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 2.0%.

4

2N3510
2N3511

CASE 27, STYLE 1
TO-52 (TO-206AC)

2N3647
2N3648

CASE 26, STYLE 1
TO-46 (TO-206AB)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3510 2N3647	2N3511 2N3648	Unit
Collector-Emitter Voltage	V_{CEO}	10	15	Vdc
Collector-Base Voltage	V_{CBO}	40	40	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		TO-46 2N3647 2N3648	TO-52 2N3510 2N3511	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.28	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 11.43	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

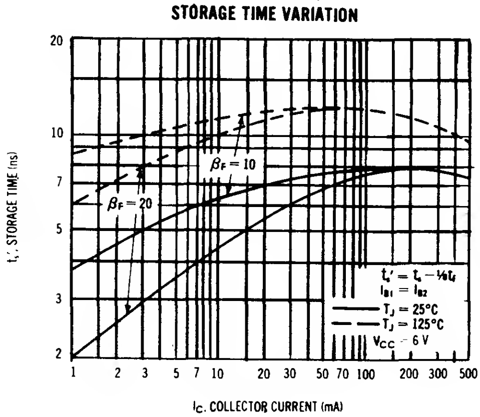
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N3510, 2N3647 2N3511, 2N3648	$V_{(BR)CEO}$	 10 15	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 10 Vdc, $V_{EB(off)}$ = 1.0 Vdc) (V_{CE} = 10 Vdc, $V_{EB(off)}$ = 1.0 Vdc, T_A = 150°C)		I_{CEX}	 — —	 .025 50	μAdc
Base Cutoff Current (V_{CE} = 10 Vdc, V_{OB} = 1.0 Vdc)		I_{BL}	—	.025	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	 2N3510, 2N3647 2N3511, 2N3648	h_{FE}	 12 15	 — —	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3510, 2N3647 2N3511, 2N3648		20 25	— —	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N3510, 2N3647 2N3511, 2N3648		25 30	150 120	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc, TA = −55°C) (I_C = 300 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648		12 15 12	— — —	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 2N3510, 2N3647 2N3511, 2N3648	$V_{CE(sat)}$	 — — — —	 0.25 0.4 0.6 0.8	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 2N3510, 2N3647 2N3511, 2N3648	$V_{BE(sat)}$	 — 0.8 — —	 0.8 1.0 1.15 1.5	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

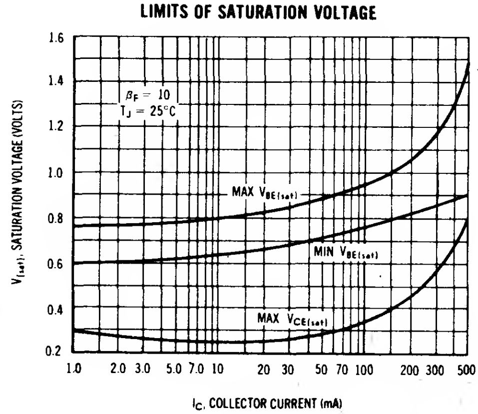
Characteristic			Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)			C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)			h_{ie}	0.6	4.5	kohms
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)			h_{re}	—	25	X 10^{-4}
Small-Signal Current Gain (I_C = 15 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		2N3510, 2N3647	h_{fe}	3.5	—	—
		2N3511, 2N3648		4.5	—	
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)				20	150	
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)			h_{oe}	10	100	μmhos
SWITCHING CHARACTERISTICS						
Delay Time	(I_C = 150 mA, I_{B1} = 15 mA, V_{EB} = 0.5 V, V_{CC} = 6.0 V)	2N3510, 2N3647	t_d	—	10	ns
		2N3511, 2N3648		—	8.0	
Rise Time		2N3510, 2N3647	t_r	—	12	ns
		2N3511, 2N3648		—	10	
Storage Time	(I_C = 150 mA, I_{B1} = $-I_{B2}$ = 15 mA, V_{CC} = 6.0 V)	2N3510, 2N3647	t_s	—	16	ns
		2N3511, 2N3648		—	12	
Fall Time		2N3510, 2N3647	t_f	—	12	ns
		2N3511, 2N3648		—	8.0	
Turn-On Time	(I_C = 150 mA, I_{B1} = 15 mA, V_{EB} = 0.5 V, V_{CC} = 6.0 V)	2N3510, 2N3647	t_{on}	—	20	ns
		2N3511, 2N3648		—	16	
Turn-Off Time	(I_C = 150 mA, I_{B1} = $-I_{B2}$ = 15 mA, V_{CC} = 6.0 V)	2N3510, 2N3647	t_{off}	—	25	ns
		2N3511, 2N3648		—	18	
Total Control Charge (I_C = 150 mA, I_B = 15 mA, V_{CC} = 6.0 V)			Q_T	—	300	pC

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

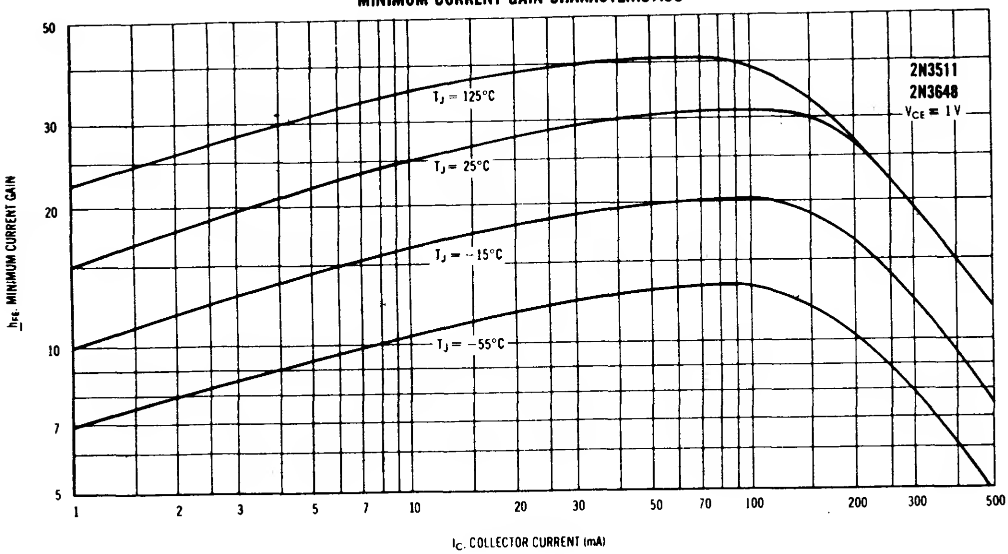
STORAGE TIME VARIATION

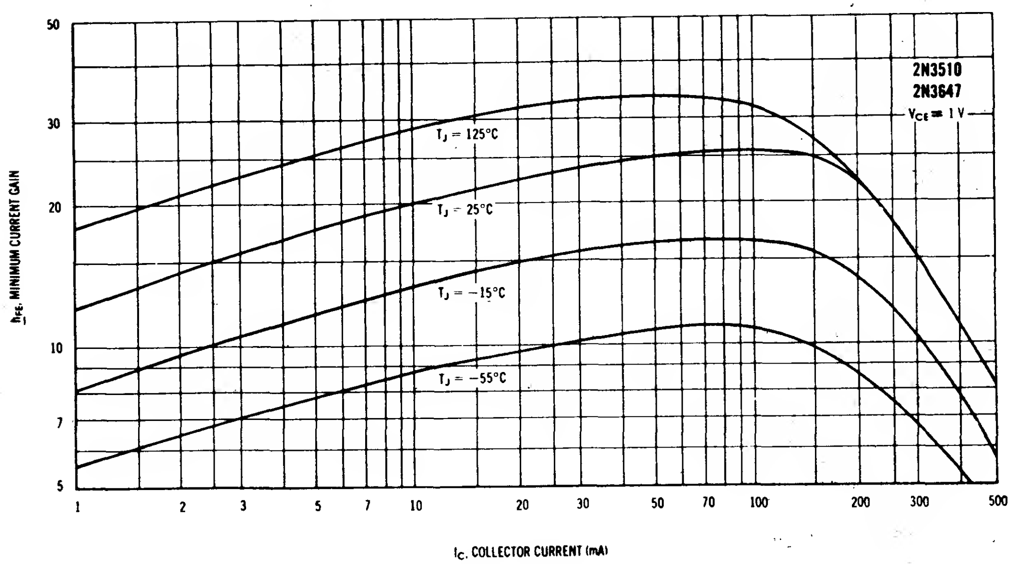


LIMITS OF SATURATION VOLTAGE



MINIMUM CURRENT GAIN CHARACTERISTICS





2N3546

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
DC Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5	—	Vdc
Base Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 3.0 Vdc)	I_{BEV}	—	0.10	μAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 3.0 Vdc)	I_{CEX}	—	0.010	μAdc
Collector Cutoff Current (V_{CB} = 10 Vdc) (V_{CB} = 10 Vdc, T_A = 150°C)	I_{CBO}	— —	0.010 10	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 20 30 15 25 15	 — 120 — — —	—
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 — — —	 0.15 0.25 0.50	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 0.7 0.8 —	 0.9 1.3 1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	5.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	I_C = 50 mA, I_{B1} = 5 .0 mA V_{BE} = 2.0 V, V_{CC} = 3.0 V	t_d	—	10	ns
Rise Time		t_r	—	15	ns
Storage Time	I_C = 50 mA, I_{B1} = I_{B2} = 5.0 mA V_{CC} = 3.0 V	t_s	—	20	ns
Fall Time		t_f	—	15	ns
Turn-On Time		t_{on}	—	40	ns
Turn-Off Time		t_{off}	—	30	ns
Total Control Charge (I_C = 50 mA, I_B = 5.0 mA, V_{CC} = 3.0 V)		Q_T	—	400	pC

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 2.0%.

4

FIGURE 1

LIMITS OF SATURATION VOLTAGES

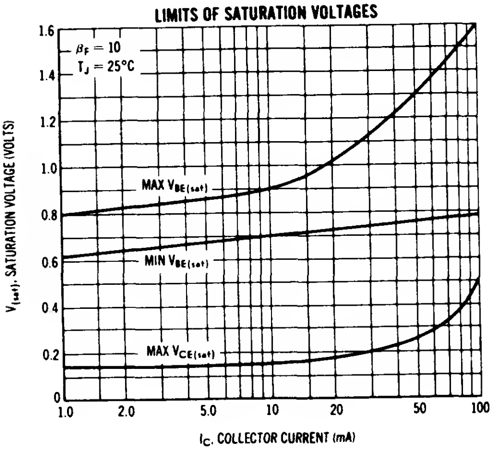


FIGURE 2

STORAGE TIME BEHAVIOR

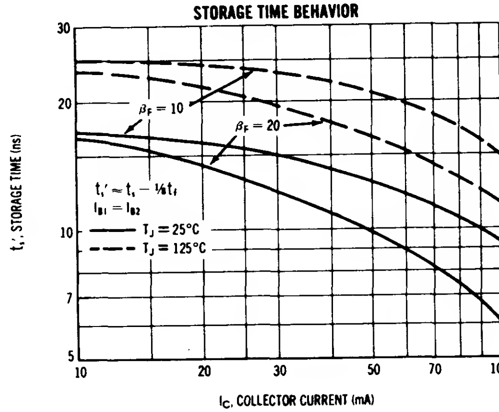
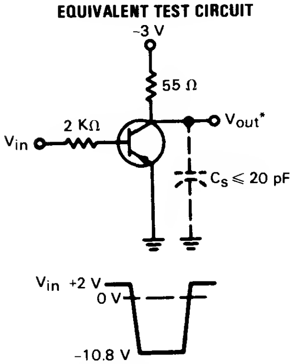


FIGURE 3

DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

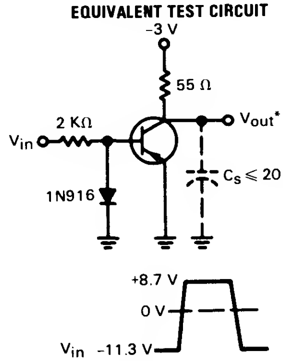


PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 10%

*OSCILLOSCOPE RISE TIME ≤ 1 ns

FIGURE 4

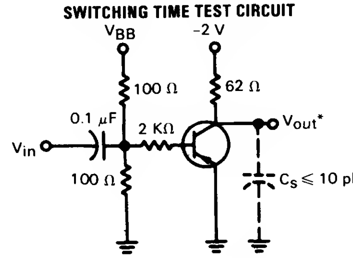
STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 10%

FIGURE 5

SWITCHING TIME TEST CIRCUIT

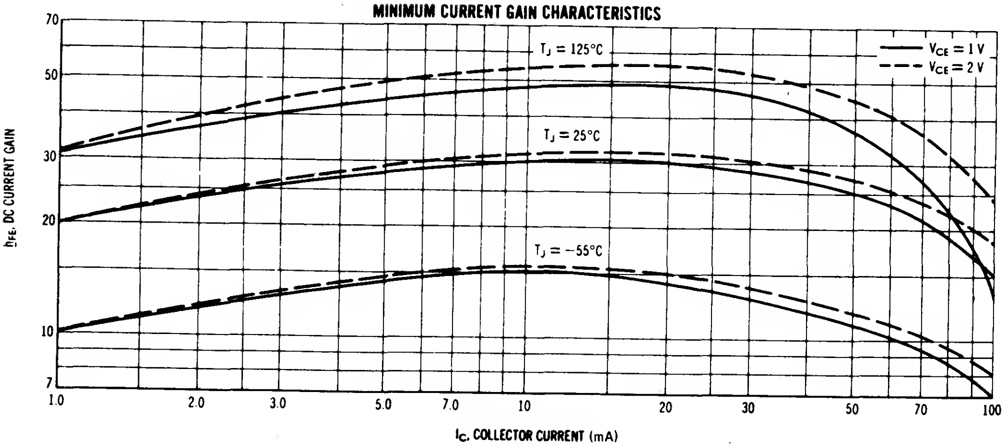


PULSE WIDTH > 200 ns
RISE TIME < 2 ns
Z_{in} = 50 Ω

t_{on}: V_{BB} = +3 V, V_{in} = -7 V
t_{off}: V_{BB} = -4 V, V_{in} = +6 V

FIGURE 6

MINIMUM CURRENT GAIN CHARACTERISTICS



4

2N3634 thru 2N3637

JAN, JTX AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-39-205AD)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3634 2N3635	2N3636 2N3637	Unit
Collector-Emitter Voltage	V_{CEO}	140	175	Vdc
Collector-Base Voltage	V_{CBO}	140	175	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N3634, 2N3635 2N3636, 2N3637	$V_{(BR)CEO}$	 140 175	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N3634, 2N3635 2N3636, 2N3637	$V_{(BR)CBO}$	 140 175	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	 2N3634, 2N3636 2N3635, 2N3637	h_{FE}	 40 80	 — —	—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637		45 90	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637		50 100	— —	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637		50 100	150 300	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637		25 50	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	 — —	 0.3 0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	 — 0.65	 0.8 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 30 Vdc, I_C = 30 mAdc, f = 100 MHz)	 2N3634, 2N3636 2N3635, 2N3637	f_T	 150 200	 — —	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	10	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	75	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3634, 2N3636 2N3635, 2N3637	h_{ie}	100 200	600 1200	ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	—	3.0	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3634, 2N3636 2N3635, 2N3637	h_{fe}	40 80	160 320	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	—	200	µmhos
Noise Figure (I_C = 0.5 mAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)		NF	—	3.0	dB

SWITCHING CHARACTERISTICS

Turn-On Time	(V_{CC} = 100 Vdc, V_{BE} = 4.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	t_{on}	—	400	ns
Turn-Off Time		t_{off}	—	600	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

4

FIGURE 1 — JUNCTION CAPACITANCE VARIATIONS

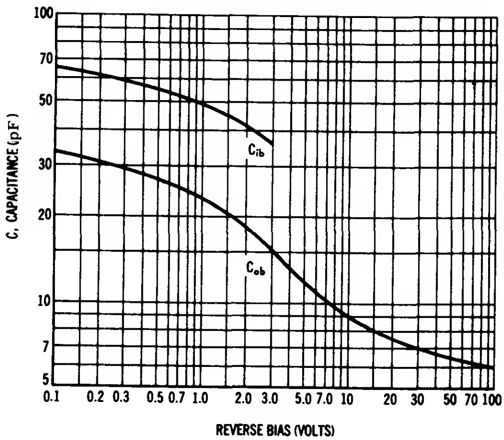


FIGURE 2 — GAIN-BANDWIDTH PRODUCT

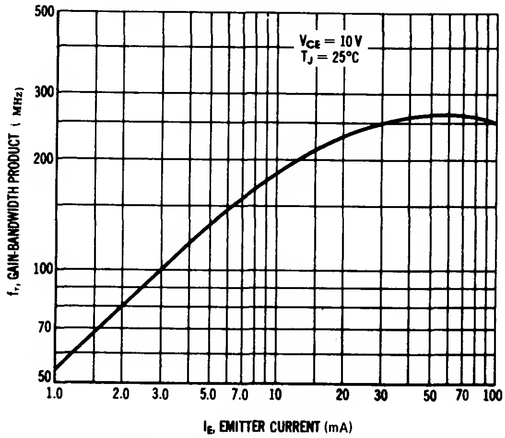
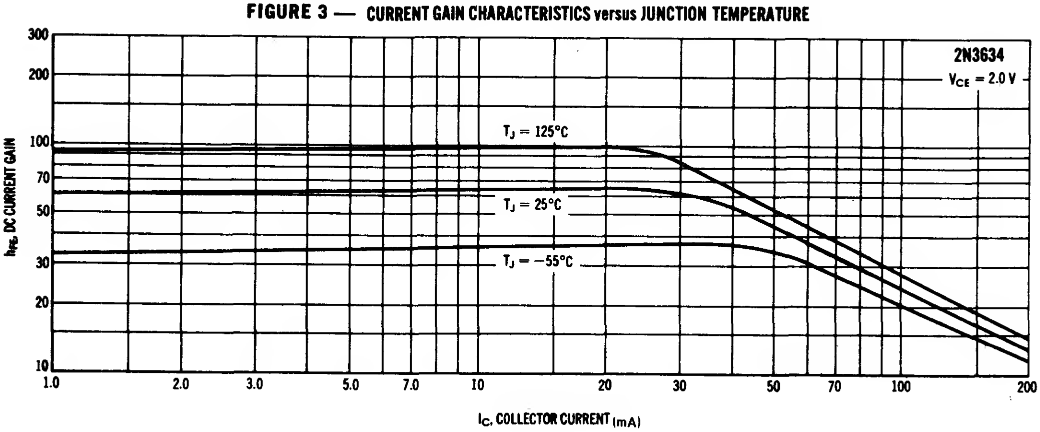


FIGURE 3 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



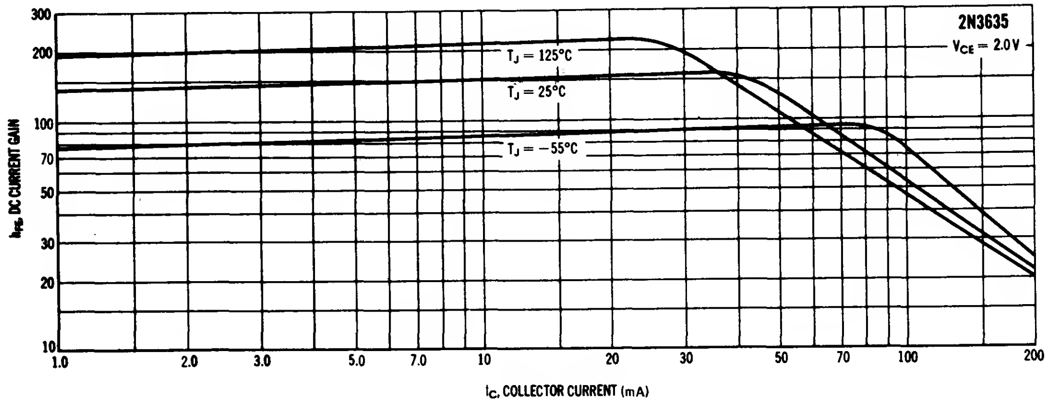


FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

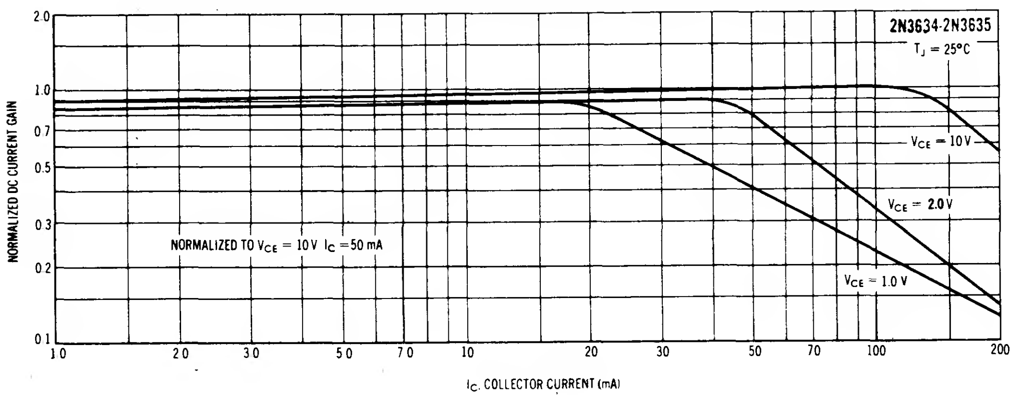
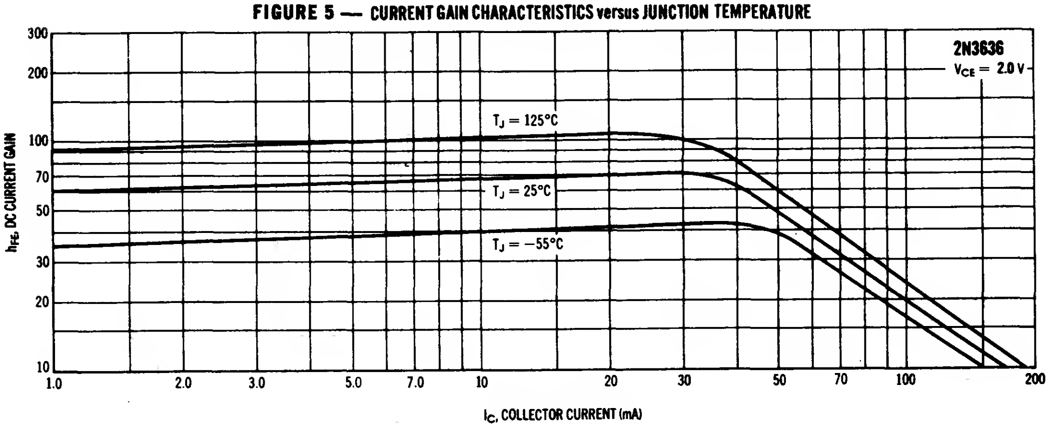


FIGURE 5 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



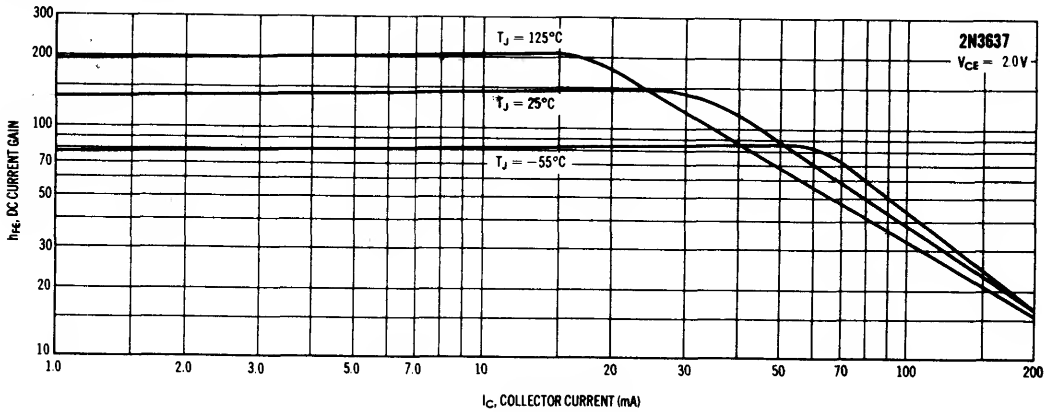


FIGURE 6 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

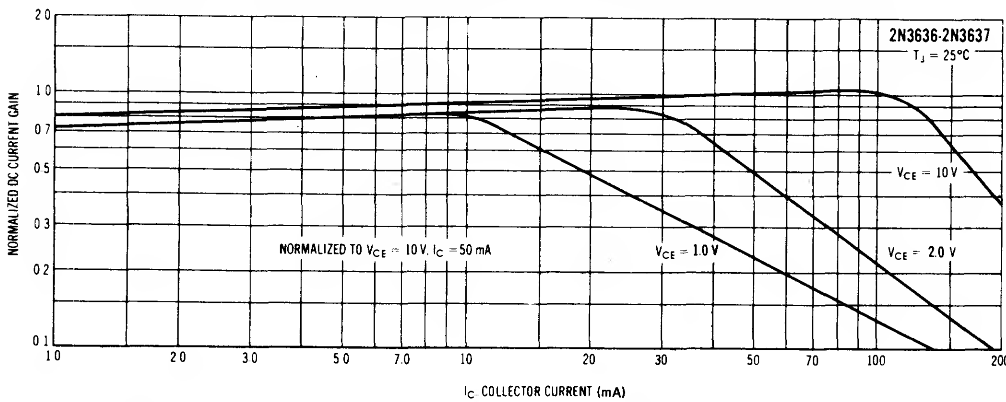


FIGURE 7 — INPUT IMPEDANCE

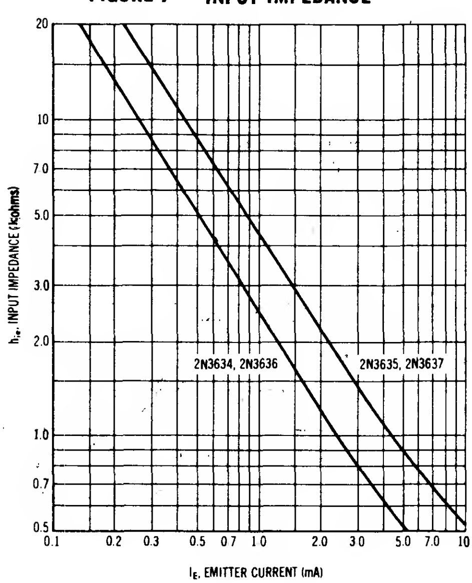


FIGURE 8 — OUTPUT IMPEDANCE

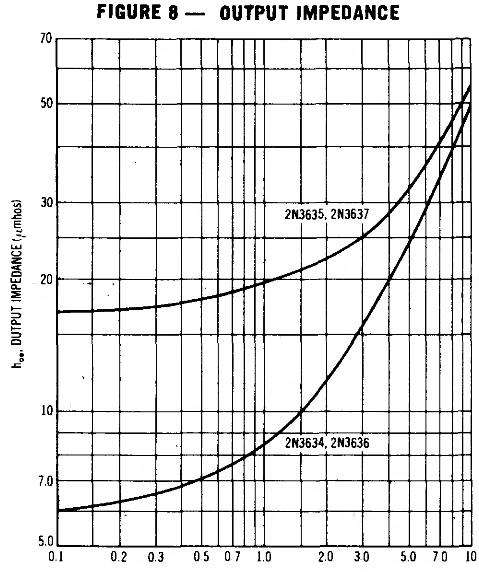


FIGURE 9 — CURRENT GAIN

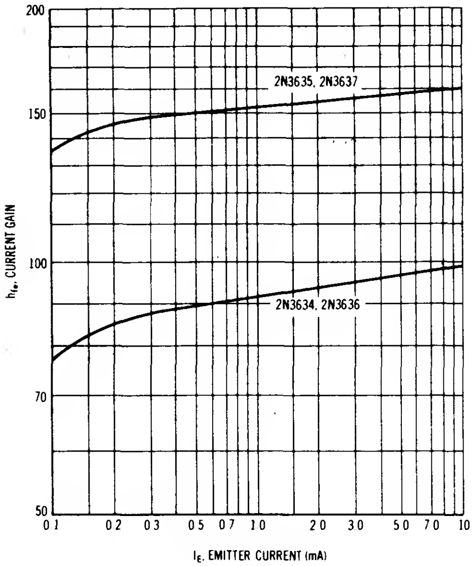


FIGURE 10 — VOLTAGE FEEDBACK RATIO

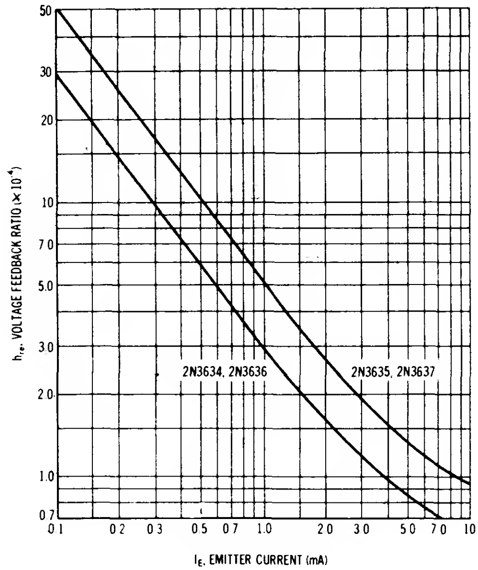


FIGURE 11 — SATURATION VOLTAGES

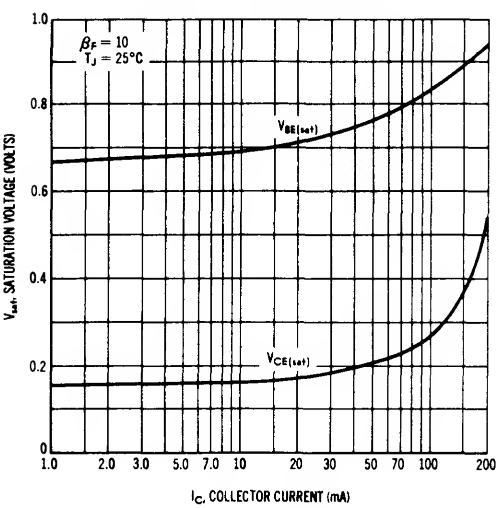


FIGURE 12 — TEMPERATURE COEFFICIENTS

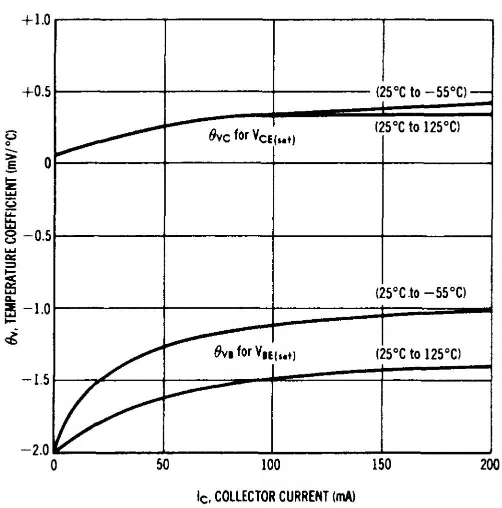
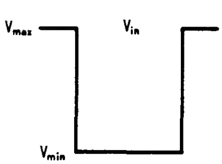


FIGURE 13 — SWITCHING TIME TEST CIRCUIT



P.W. ≅ 20 μs
DUTY CYCLE ≤ 2%
RISE TIME ≤ 20 ns

	V_{max}	V_{min}
TURN-ON	+4.0 V	−5.65 V
TURN-OFF	+4.1 V	−5.9 V

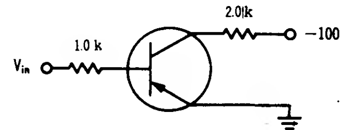


FIGURE 14 — TURN-ON TIME VARIATIONS WITH VOLTAGE

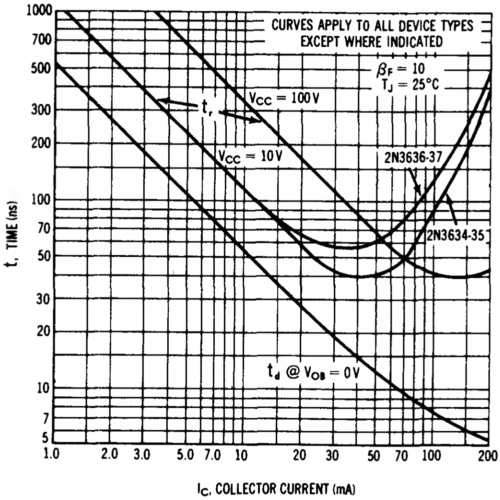
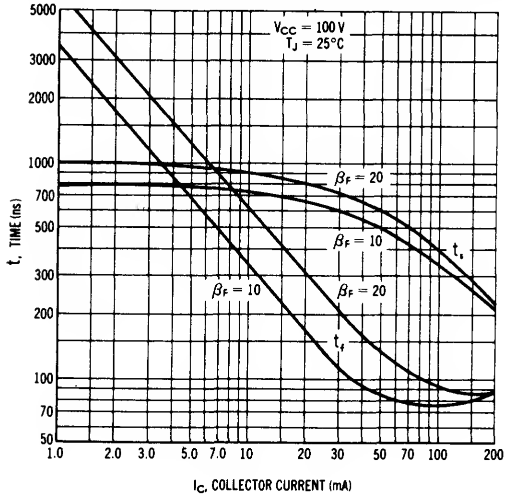


FIGURE 15 — TURN-OFF TIME VARIATIONS WITH CIRCUIT GAIN*



2N3647, 2N3648

For Specifications, See 2N3510 Data.

2N3677

CASE 026-03, STYLE 1
TO-46 (TO-206AB)

LOW POWER CHOPPER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	20	V
Collector-Base Voltage	V_{CBO}	30	V
Emitter-Base Voltage	V_{EBO}	30	V
Collector Current — Continuous	I_C	100	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Emitter-Collector Breakdown Voltage ($I_C = 1.0$ nA)	$V_{(BR)ECS}$	20	—	V
Collector-Base Breakdown Voltage ($I_C = 1.0$ mA)	$V_{(BR)CBO}$	30	—	V
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mA)	$V_{(BR)EBO}$	30	—	V
Collector Cutoff Current ($V_{CB} = 30$ V)	I_{CBO}	—	1.0	nA
Emitter Cutoff Current ($V_{EB} = 30$ V)	I_{EBO}	—	1.0	nA
ON CHARACTERISTICS				
Offset Voltage ($I_B = 1.0$ mA)	$V_{EC(ofs)}$	—	1.0	mV
Common-Collector static forward transfer ratio ($I_E = 1.0$ mA, $V_{EC} = 6.0$ V)	h_{fe}	4.0	—	—
On series resistance ($I_B = 1.0$ mA)	r_s	0.1	8.0	ohms
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 6.0$ V, f = 159 kHz)	C_{obo}	—	10	pF
Input Capacitance ($V_{EB} = 6.0$ V, f = 159 kHz)	C_{ibo}	—	6.0	pF
Magnitude of Forward Current Transfer Ratio, Common-Emitter ($I_C = 1.0$ mA, $V_{CE} = 6.0$ V, f = 1.0 MHz)	$\lvert h_{fe} \rvert$	5.0	—	—

2N3724
2N3725

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3724	2N3725	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	50	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 2.0		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N3725 2N3724	$V_{(BR)CEO}$	 50 30	 — —	 — —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	 2N3725 2N3724	$V_{(BR)CES}$	 80 50	 — —	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N3725 2N3724	$V_{(BR)CBO}$	 80 50	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	 2N3725 2N3724 2N3725 2N3724	I_{CBO}	 — — — —	 0.12 0.12 — —	 1.7 1.7 120 120	μAdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{EB} = 0) (V_{CE} = 50 Vdc, V_{EB} = 0)	 2N3725 2N3724	I_{CES}	 — —	 0.15 0.15	 10 10	μAdc
Base Current (V_{CE} = 50 V, V_{EB} = 0) (V_{CE} = 80 V, V_{EB} = 0)	 2N3724 2N3725	I_B	—	—	10	μAdc
ON CHARACTERISTICS(1)						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 300 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 800 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 800 mA, V_{CE} = 2.0 V) (I_C = 1.0 Adc, V_{CE} = 5.0 V)	 2N3725 2N3725	h_{FE}	 30 60 30 40 35 20 25 30 20 25	 — — — — — — — — — —	 — 150 — — — — — — — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	 2N3725 2N3724	$V_{CE(sat)}$	— —	 0.17 0.17	 0.25 0.25	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

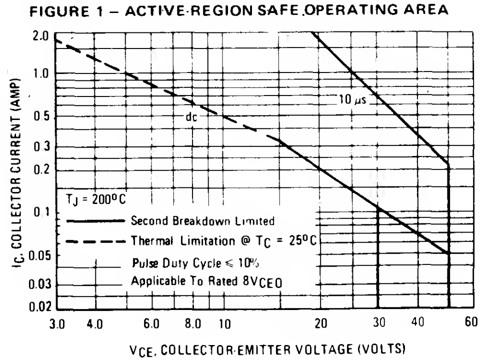
Characteristic		Symbol	Min	Typ	Max	Unit
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3725		—	0.19	0.26	
	2N3724		—	0.19	0.20	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3725		—	0.25	0.40	
	2N3724		—	0.25	0.32	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3725		—	0.30	0.52	
	2N3724		—	0.30	0.42	
(I_C = 800 mAdc, I_B = 80 mAdc)	2N3725		—	0.43	0.80	
	2N3724		—	0.43	0.65	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3725		—	0.55	0.95	
	2N3724		—	0.55	0.75	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	—	0.76	
(I_C = 100 mAdc, I_B = 10 mAdc)			—	—	0.86	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	—	1.1	
(I_C = 800 mAdc, I_B = 80 mAdc)			—	—	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	—	1.7	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N3725	C_{obo}	—	—	10	pF
	2N3724		—	—	12	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	—	55	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 1.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

SWITCHING CHARACTERISTICS

Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)	t_d	–	5.0	10	ns
Rise Time		t_r	–	15	30	ns
Turn-On Time		t_{on}	–	20	35	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10)	t_s	–	35	50	ns
Fall Time		t_f	–	20	25	ns
Turn-Off Time		t_{off}	–	50	60	ns

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

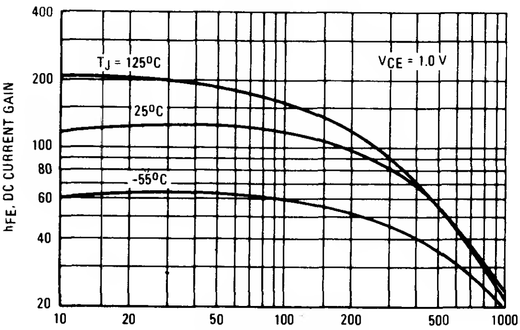


FIGURE 3 – "ON" VOLTAGES

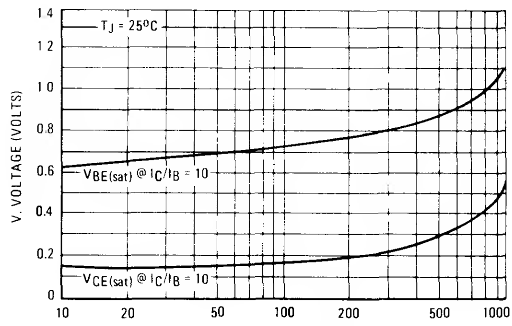


FIGURE 4 – COLLECTOR SATURATION REGION

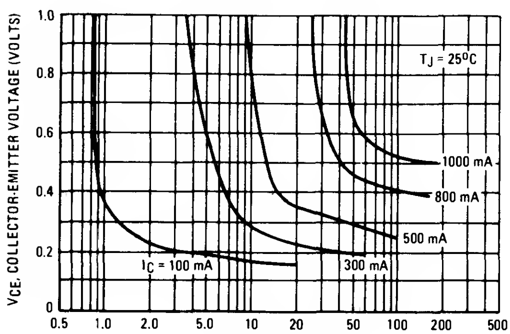
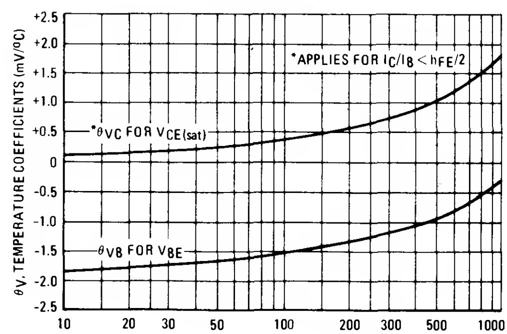


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

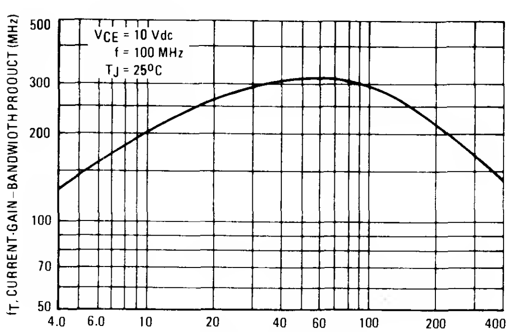


FIGURE 7 – CAPACITANCE

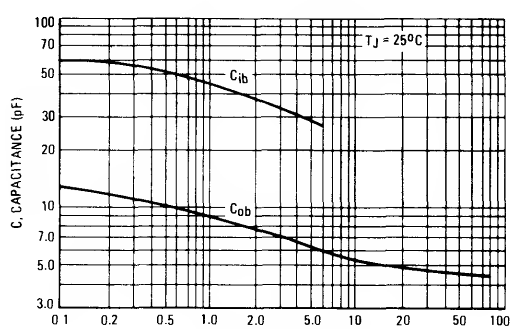


FIGURE 8 – TURN-ON TIME

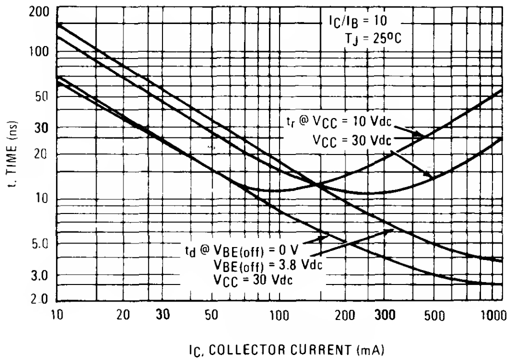


FIGURE 9 – TURN-OFF TIME

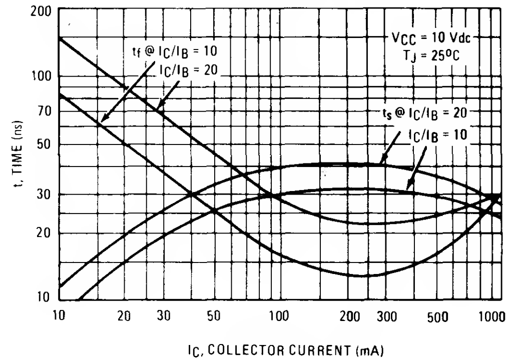


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

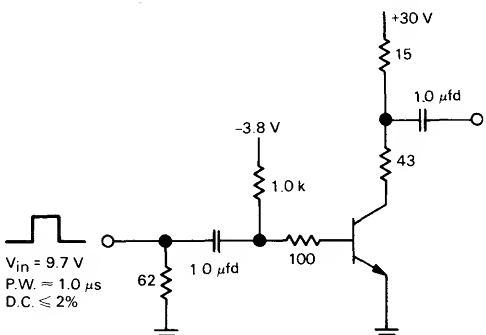
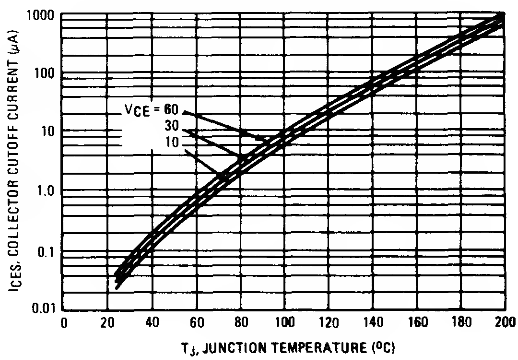


FIGURE 11 – COLLECTOR CUTOFF CURRENT



4

2N3734
2N3735

CASE 79, STYLE 1
TO-39 (TO-205AD)

2N3736
2N3737

CASE 26, STYLE 1
TO-46 (TO-206AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

Refer to 2N3725 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N3734 2N3736	2N3735 2N3737	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	50	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		TO-39 2N3734 2N3735	TO-46 2N3736 2N3737	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3734 2N3736	2N3735 2N3737	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.044	0.088	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.175	0.35	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

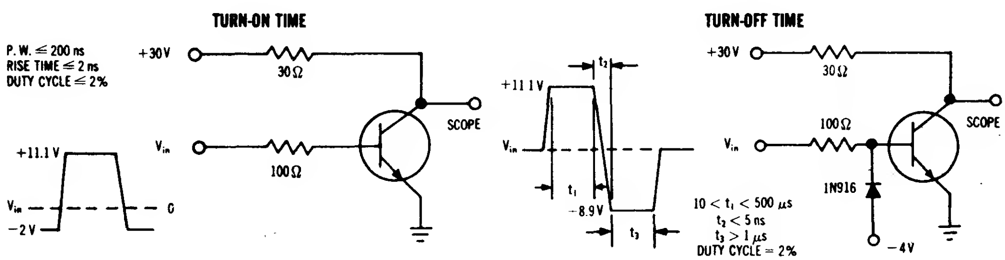
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 2N3734, 2N3736 2N3735, 2N3737	$V_{(BR)CEO}$	 30 50	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	 2N3734, 2N3736 2N3735, 2N3737	$V_{(BR)CBO}$	 50 75	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 25$ Vdc, $V_{EB} = 2$ Vdc) ($V_{CE} = 25$ Vdc, $V_{EB} = 2$ Vdc, $T_A = 100°C$) ($V_{CE} = 40$ Vdc, $V_{EB} = 2$ Vdc) ($V_{CE} = 40$ Vdc, $V_{EB} = 2$ Vdc, $T_A = 100°C$)	 2N3734, 2N3736 2N3735, 2N3737 	I_{CEX}	 — — — —	 0.20 20 0.20 20	μAdc
Base Cutoff Current ($V_{CE} = 25$ Vdc, $V_{EB} = 2$ Vdc) ($V_{CE} = 40$ Vdc, $V_{EB} = 2$ Vdc)	 2N3734, 2N3736 2N3735, 2N3737	I_{BL}	 — —	 0.3 0.3	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 10$ mAdc, $V_{CE} = 1$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 1$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1$ Vdc) ($I_C = 1$ Adc, $V_{CE} = 1.5$ Vdc) ($I_C = 1.5$ Adc, $V_{CE} = 5$ Vdc)	 2N3734, 2N3736 2N3735, 2N3737 2N3734, 2N3736 2N3735, 2N3737	h_{FE}	 35 40 35 30 20 30 20	 — — — 120 80 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1$ mAdc) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1$ Adc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	 — — — —	 0.2 0.3 0.5 0.9	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1$ mAdc) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1$ Adc, $I_B = 100$ mAdc)		$V_{BE(sat)}$	 — — — 0.9	 0.8 1.0 1.2 1.4	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	9.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	80	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	2.5	—	—
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 30 V, $V_{BE(off)}$ = 2.0 V, I_C = 1.0 Amp, I_{B1} = 100 mA)	t_{on}	—	40	ns
Turn-Off Time (V_{CC} = 30 V, $V_{BE(off)}$ = 2.0 V, I_C = 1.0 Amp, I_{B1} = 100 mA)	t_{off}	—	60	ns
Total Control Charge (I_C = 1 Amp, I_B = 100 mA, V_{CC} = 30 V)	Q_T	—	10	pC

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS



2N3742

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 200$ Vdc, $I_E = 0$, $T_A = 100°C$)	I_{CBO}	 — —	 0.2 20	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.2	μAdc
ON CHARACTERISTICS(2)				
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc)	h_{FE}	 10 15 20 20	 — — 200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	$V_{CE(sat)}$	 — —	 0.75 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	$V_{BE(sat)}$	 — —	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(3) ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)	f_T	30	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	80	pF
Input Impedance ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ie}	—	2.0	k ohms
Voltage Feedback Ratio ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{re}	—	2.0	$X10^{-4}$
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 10 kHz)	h_{fe}	20	200	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	—	50	mhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)	$Re(h_{ie})$	—	200	Ohms

(1) Pulse Test: Pulse Width ≤ 30 μs, Duty Cycle ≤ 1.0%.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – DC CURRENT GAIN

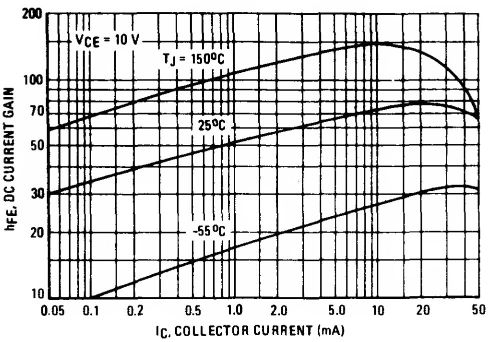


FIGURE 2 – DC SAFE OPERATING AREA

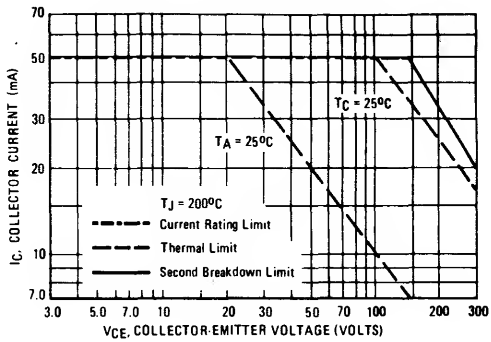


FIGURE 3 – "ON" VOLTAGES

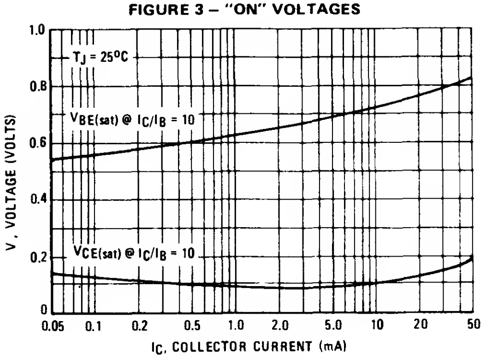


FIGURE 4 – TEMPERATURE COEFFICIENTS

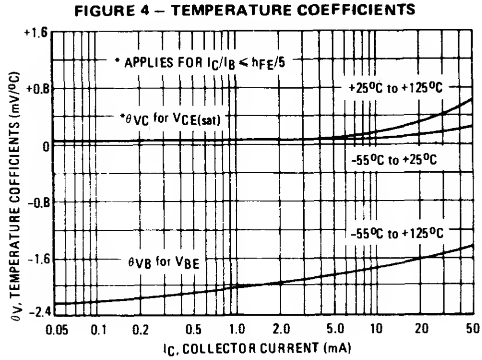


FIGURE 5 – CURRENT-GAIN-BANDWIDTH PRODUCT

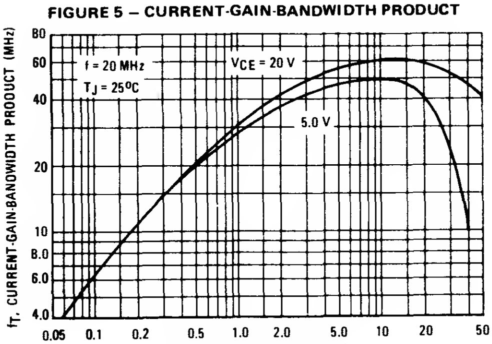
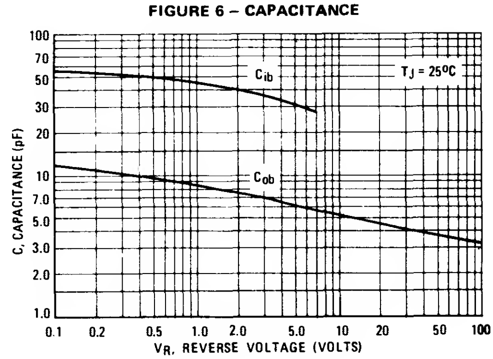


FIGURE 6 – CAPACITANCE



2N3743

JAN, JTX AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

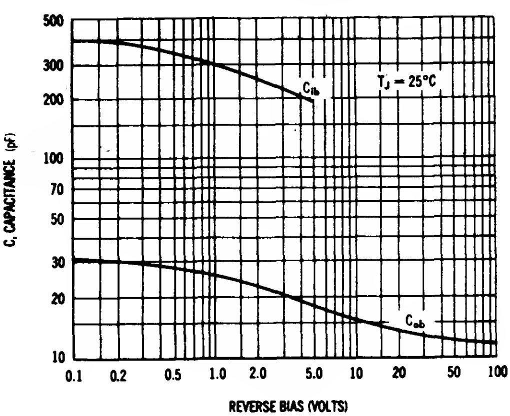
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 0.3 30	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain(2) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 20 Vdc)	h_{FE}	 20 25 25 25 25	 — — — 250 —	—
Collector-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 30 mAdc, I_B = 3 mAdc)	$V_{CE(sat)}$	 — —	 5.0 8.0	Vdc
Base-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 30 mAdc, I_B = 3 mAdc)	$V_{BE(sat)}$	 — —	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	15	pF
Input Capacitance (V_{EB} = 1.0 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	400	pF
Input Impedance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{ie}	—	1.0	kohms
Voltage Feedback Ratio (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{re}	—	4.0	X 10^{-4}
Small-Signal Current Gain (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{fe}	30	300	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

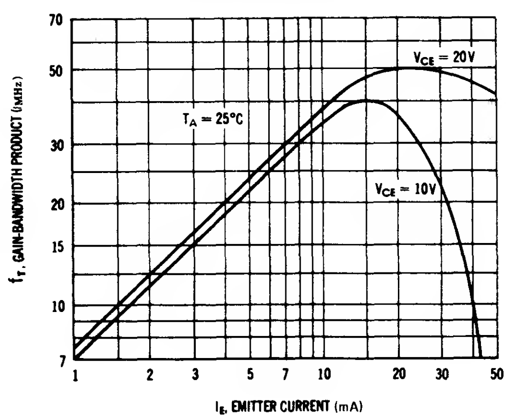
Characteristic	Symbol	Min	Max	Unit
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	$\|h_{fe}\|$	1.5	—	—
Output Admittance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{oe}	—	200	μmhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5 MHz)	$Re(h_{ie})$	—	40	ohms

(1) PW ≤ 30 μs, Duty Cycle ≤ 1.0%.
(2) PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

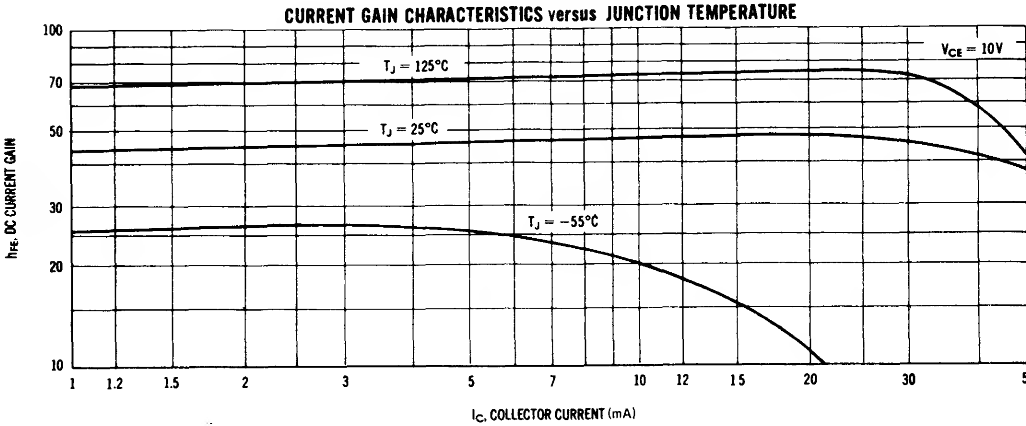
JUNCTION CAPACITANCE



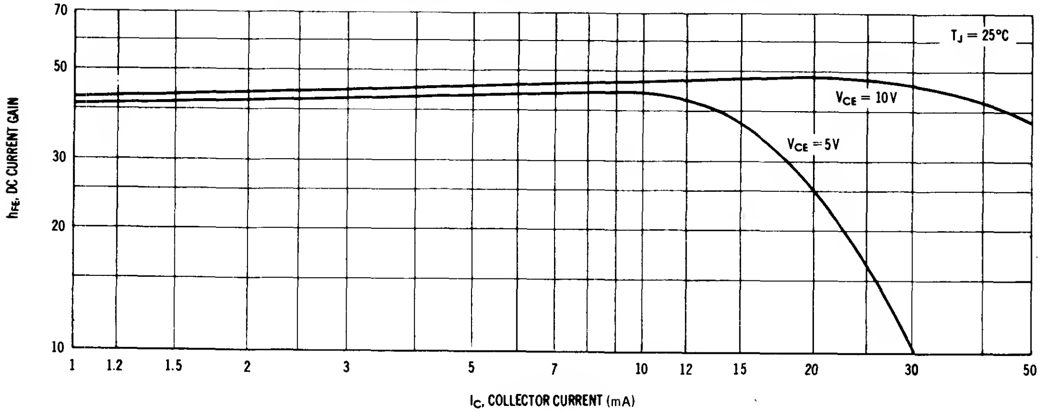
GAIN-BANDWIDTH PRODUCT



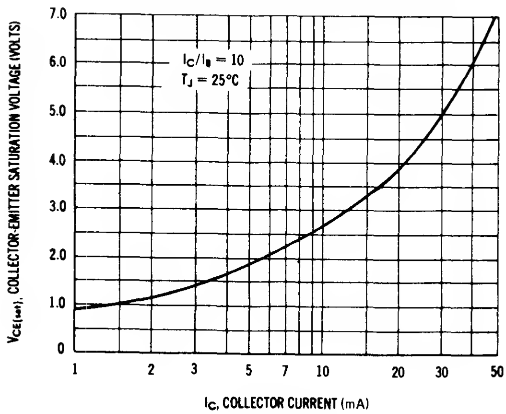
CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



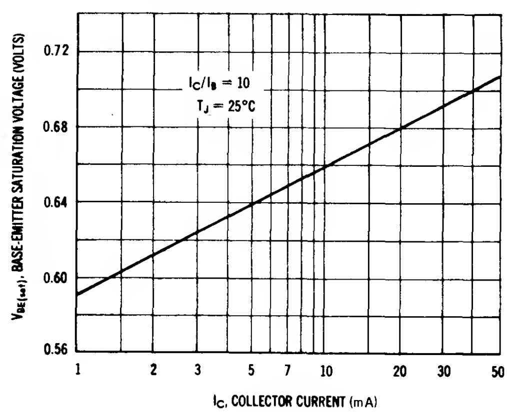
CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



COLLECTOR-EMITTER SATURATION VOLTAGE



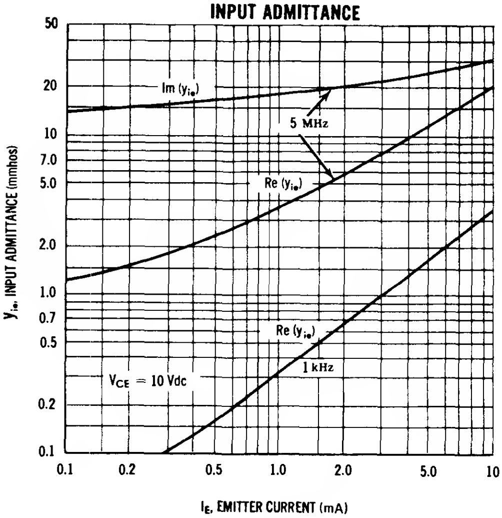
BASE-EMITTER SATURATION VOLTAGE



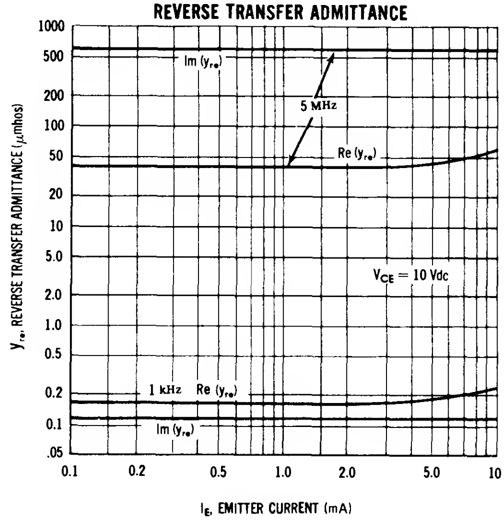
SMALL SIGNAL *y* PARAMETERS

$T_A = 25°C$

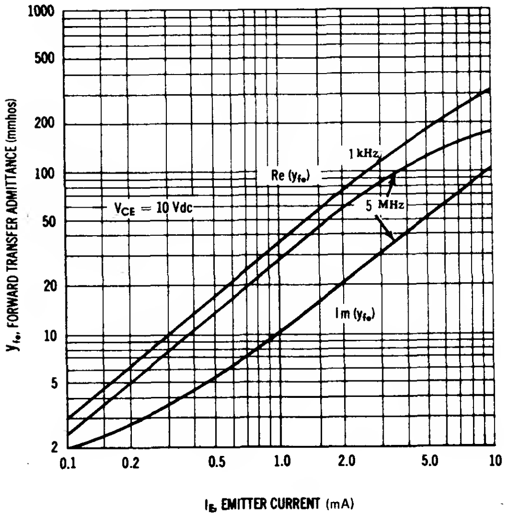
INPUT ADMITTANCE



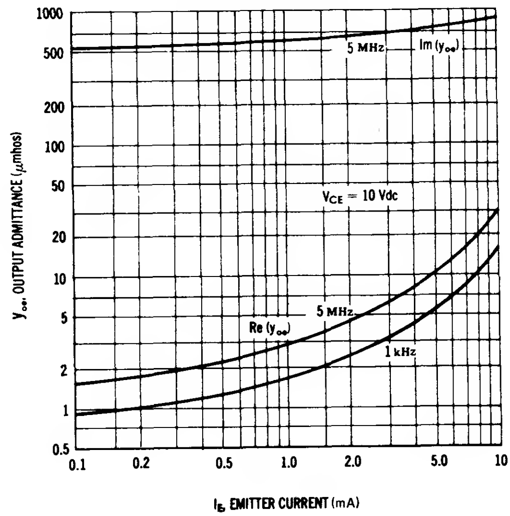
REVERSE TRANSFER ADMITTANCE



FORWARD TRANSFER ADMITTANCE



OUTPUT ADMITTANCE



4

2N3762, 2N3763
2N3764, 2N3765

JAN, JTX, JTXV AVAILABLE
CASE 79, CASE 26, STYLE 1
TO-39, TO-46

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3762 2N3764	2N3763 2N3765	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	40	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		TO-5 2N3762 2N3763	TO-46 2N3764 2N3765	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Lead Temperature 1/16″ from Case for 10 Seconds	T_L	+235		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3762 2N3763	2N3764 2N3765	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	44	88	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	350	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N3762, 2N3764 2N3763, 2N3765	$V_{(BR)CEO}$	 40 60	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N3762, 2N3764 2N3763, 2N3765	$V_{(BR)CBO}$	 40 60	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{EB} = 2.0 Vdc) (V_{CE} = 20 Vdc, V_{EB} = 2.0 Vdc, T_A = 100°C) (V_{CE} = 30 Vdc, V_{EB} = 2.0 Vdc) (V_{CE} = 30 Vdc, V_{EB} = 2.0 Vdc, T_A = 100°C)	 2N3762, 2N3764 2N3763, 2N3765 	I_{CEX}	 — — — —	 0.10 10 0.10 10	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, V_{EB} = 2.0 Vdc) (V_{CE} = 30 Vdc, V_{EB} = 2.0 Vdc)	 2N3762, 2N3764 2N3763, 2N3765	I_{BL}	 — —	 0.2 0.2	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.5 Vdc) (I_C = 1.5 Adc, V_{CE} = 5.0 Vdc)	 2N3762, 2N3764 2N3763, 2N3765 2N3762, 2N3764 2N3763, 2N3765	h_{FE}	 35 40 35 30 20 30 20	 — — — 120 80 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{CE(sat)}$	 — — — —	 0.1 0.22 0.5 0.9	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	 — — — 0.9	 0.8 1.0 1.2 1.4	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

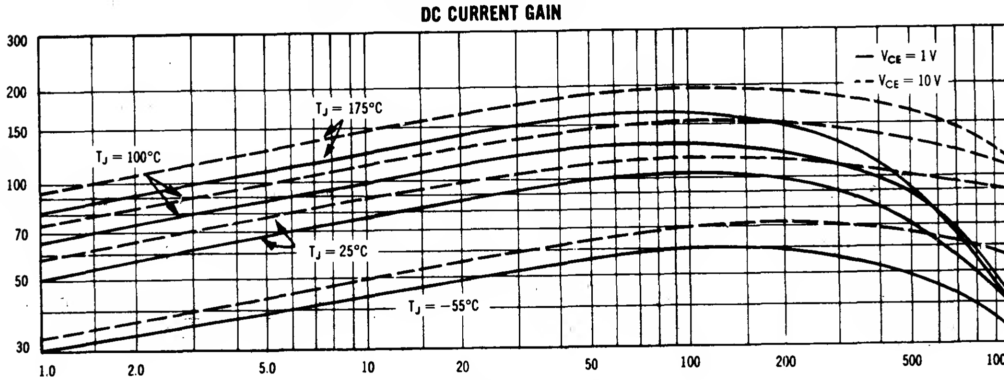
Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	80	pF
Current Gain — High Frequency (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3762, 2N3764 2N3763, 2N3765	$\|h_{fe}\|$	1.8 1.5	— —	—
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 V, $V_{BE(off)}$ = 2.0 V, I_C = 1.0 Amp, I_{B1} = 100 mA)	t_d	—	8.0	ns
Rise Time		t_r	—	3.5	ns
Storage Time	(V_{CC} = 30 V, I_C = 1.0 Amp, I_{B1} = $-I_{B2}$ = 100 mA)	t_s	—	80	ns
Fall Time		t_f	—	35	ns
Total Control Charge (I_C = 1.0 Amp, I_B = 100 mA, V_{CC} = 30 V)		Q_T	—	30	pC

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

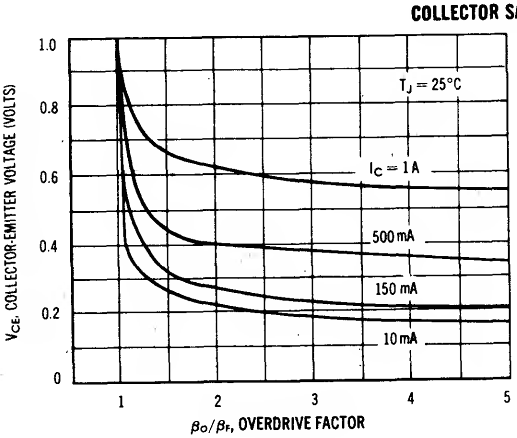
4

"ON" CONDITION CHARACTERISTICS

DC CURRENT GAIN



COLLECTOR SATURATION REGION



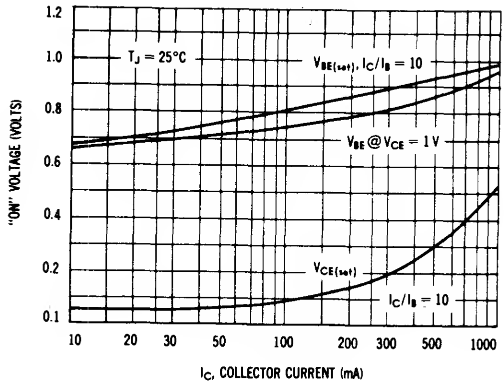
This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3734, estimate a base current (I_{BF}) to ensure saturation at a temperature of 25°C and a collector of 500 mA.

Observe that at I_C = 500 mA an overdrive factor of at least 2.0 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 54 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design).

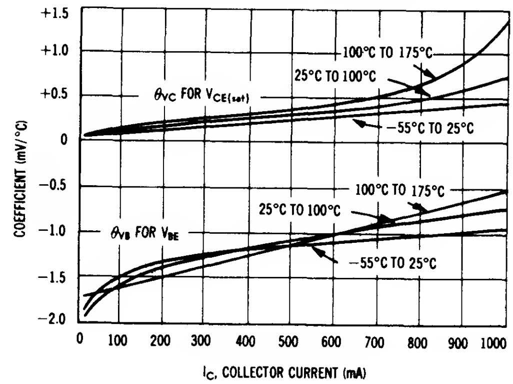
$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\ \text{Volt}}{I_C/I_{BF}} \qquad 2 = \frac{54}{500\ \text{mA}/I_{BF}} \qquad I_{BF} \approx 18.5\ \text{mA typ}$$

4

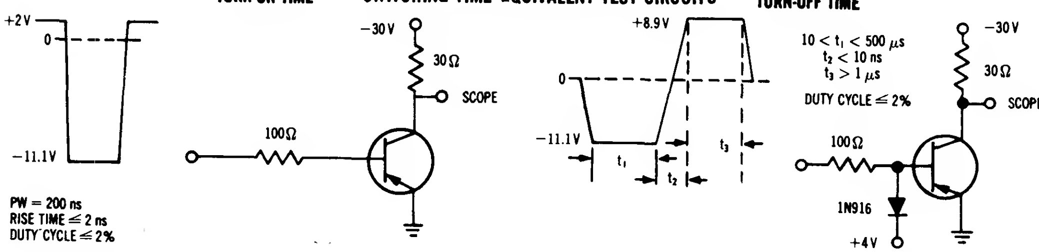
"ON" VOLTAGES



TEMPERATURE COEFFICIENTS

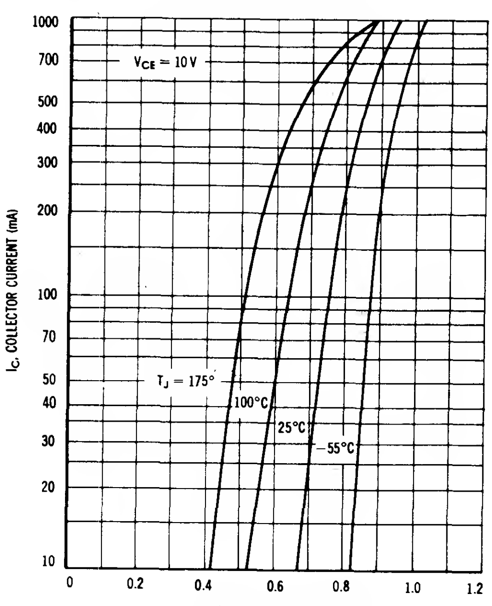


TURN-ON TIME — SWITCHING TIME EQUIVALENT TEST CIRCUITS — TURN-OFF TIME



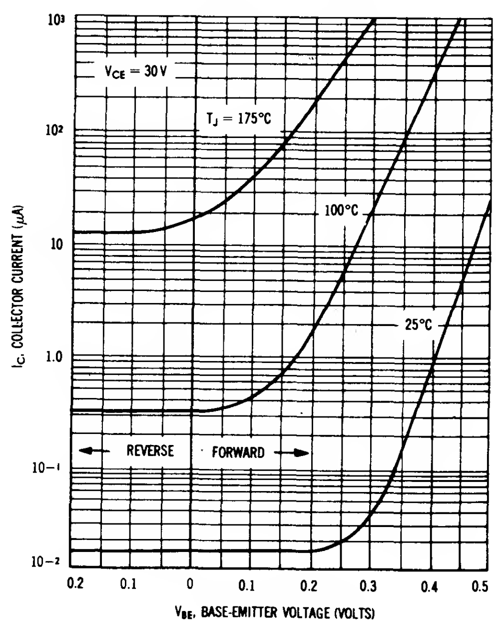
LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

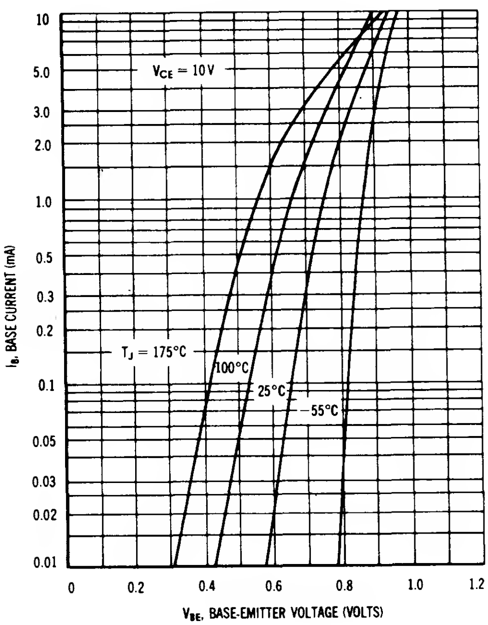


"OFF" CONDITION CHARACTERISTICS

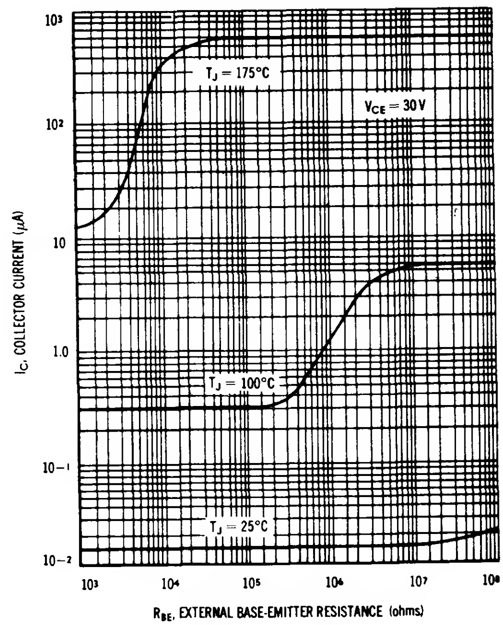
TRANSCONDUCTANCE



INPUT ADMITTANCE



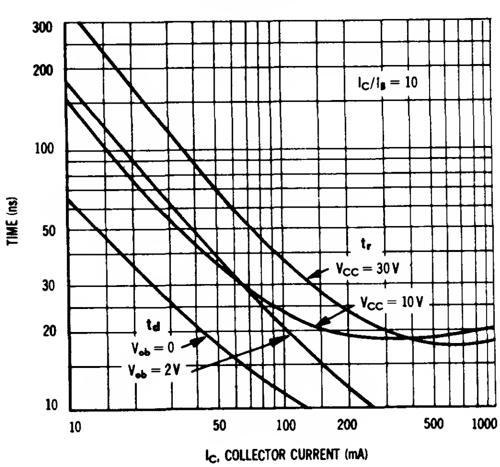
EFFECT OF BASE-EMITTER RESISTANCE



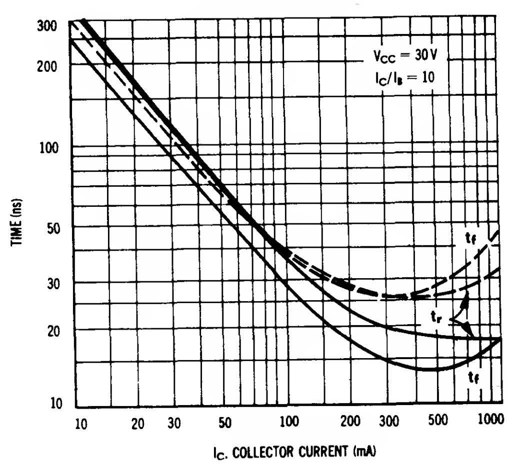
SWITCHING CHARACTERISTICS

— $T_J = 25°C$ -- $T_J = 150°C$

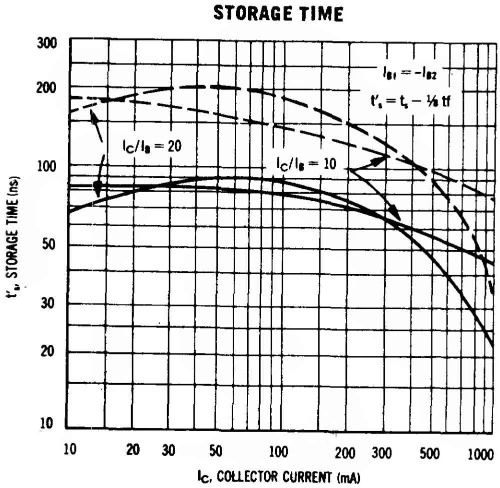
TURN-ON TIME

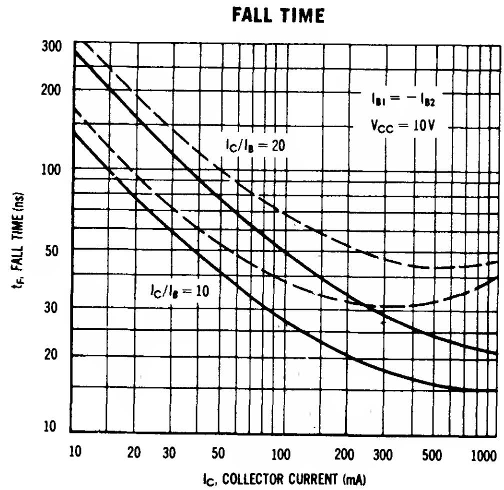


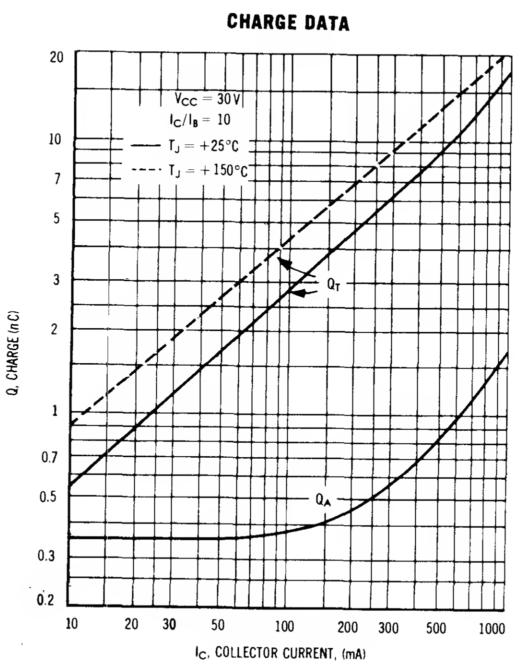
RISE AND FALL TIME

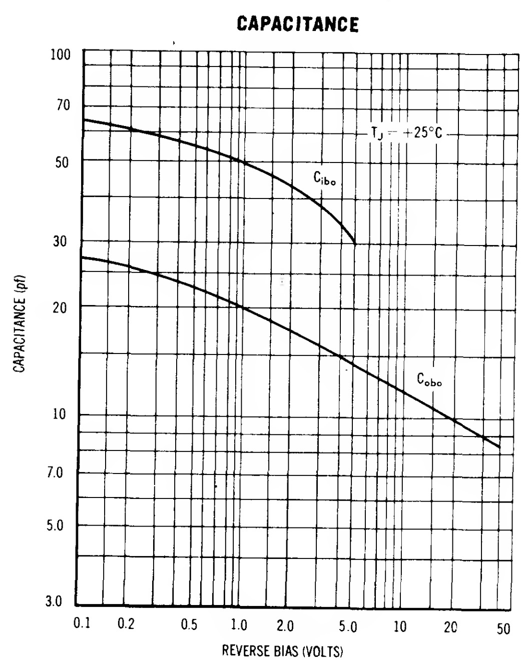


4

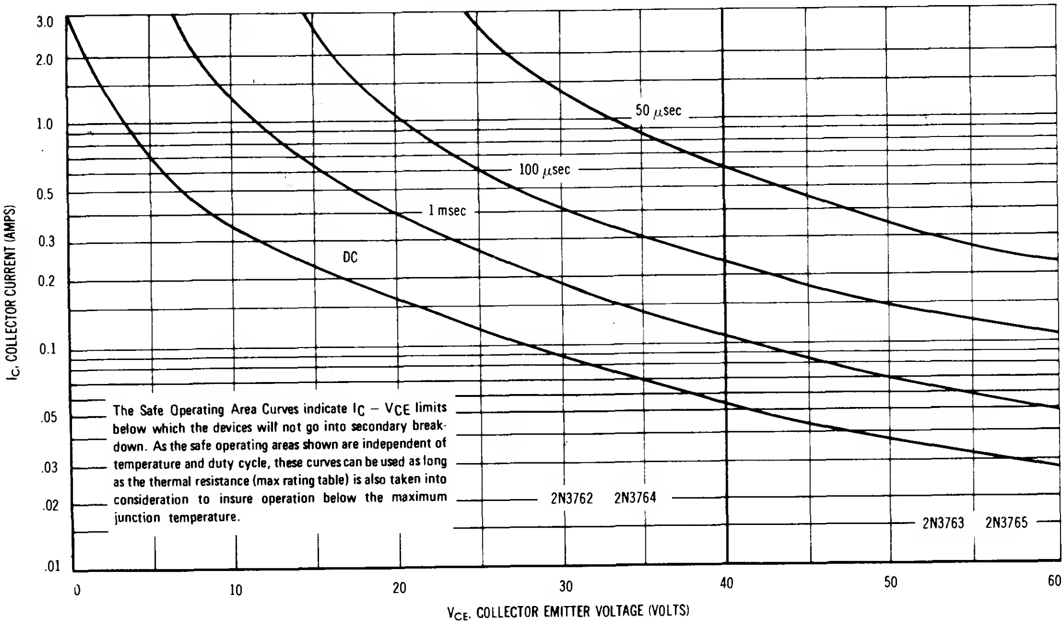

STORAGE TIME
$I_{B1} = -I_{B2}$
$t'_s = t_s - 1/8\,t_f$
$I_C/I_B = 20$
$I_C/I_B = 10$
t'_s, STORAGE TIME (ns)
I_C, COLLECTOR CURRENT (mA)


FALL TIME
$I_{B1} = -I_{B2}$
$V_{CC} = 10V$
$I_C/I_B = 20$
$I_C/I_B = 10$
t_f, FALL TIME (ns)
I_C, COLLECTOR CURRENT (mA)


CHARGE DATA
$V_{CC} = 30V$
$I_C/I_B = 10$
$T_J = +25°C$
$T_J = +150°C$
Q_T
Q_A
Q, CHARGE (nC)
I_C, COLLECTOR CURRENT, (mA)


CAPACITANCE
$T_J = +25°C$
C_{ibo}
C_{obo}
CAPACITANCE (pf)
REVERSE BIAS (VOLTS)

ACTIVE REGION SAFE OPERATING AREAS



2N3798
2N3799

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3798 2N3799	2N3798A 2N3799A	Unit
Collector-Emitter Voltage	V_{CEO}	60	90	Vdc
Collector-Base Voltage	V_{CBO}	60	90	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.86		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	2N3798, 2N3799	$V_{(BR)CEO}$	60	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3798, 2N3799	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	— —	— —	0.01 10	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
(I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	2N3799		75	—	—	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N3798 2N3799		100 225	— —	— —	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3798 2N3799		150 300	— —	— —	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)	2N3798 2N3799		75 150	— —	— —	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	2N3798 2N3799		150 300	— —	450 900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N3798 2N3799		150 300	— —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N3798 2N3799		125 250	— —	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$	— —	— —	0.2 0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	— —	— —	0.7 0.8	Vdc
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	—	0.7	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2)		f_T				MHz
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)			30	—	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)			100	—	500	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3798	h_{ie}	3.0	—	15	k ohms
	2N3799		10	—	40	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	—	—	25	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3798	h_{fe}	150	—	600	—
	2N3799		300	—	900	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	5.0	—	60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_G = 3.0 k ohms), f = 100 Hz, B.W. = 20 Hz	2N3798	NF	—	4.0	7.0	dB
	2N3799		—	2.5	4.0	
Spot Noise f = 1.0 kHz, B.W. = 200 Hz	2N3798		—	1.5	3.0	
	2N3799		—	0.8	1.5	
f = 10 kHz, B.W. = 2.0 kHz	2N3798		—	1.0	2.5	
	2N3799		—	0.8	1.5	
Broadband Noise-Bandwidth 10 Hz to 15.7 kHz	2N3798		—	2.5	3.5	
	2N3799		—	1.5	2.5	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

4

SPOT NOISE FIGURE
(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 1 — SOURCE RESISTANCE EFFECTS, f = 1.0 kHz

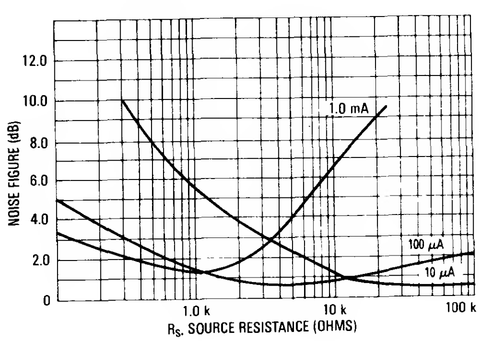


FIGURE 2 — SOURCE RESISTANCE EFFECTS, f = 10 Hz

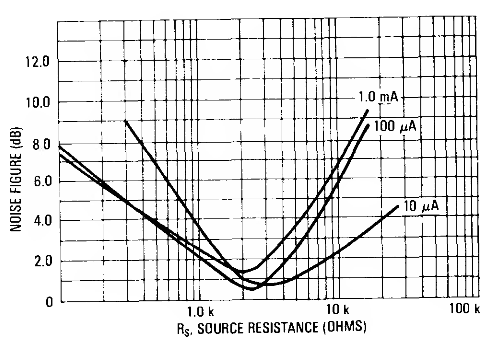


FIGURE 3 — FREQUENCY EFFECTS

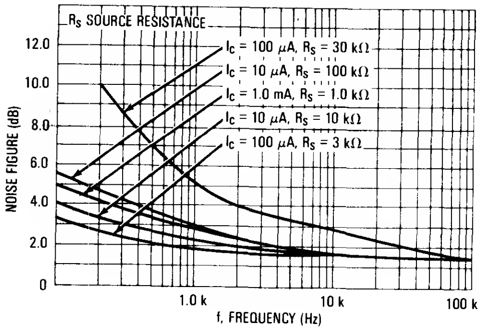


FIGURE 4a — TYPICAL CURRENT GAIN CHARACTERISTICS—2N3798

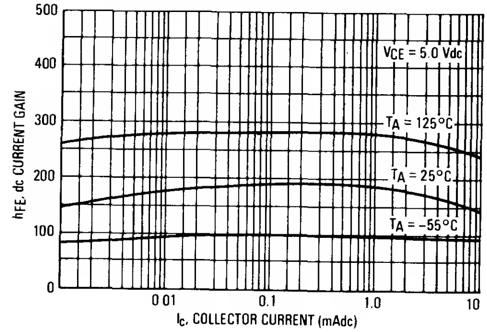
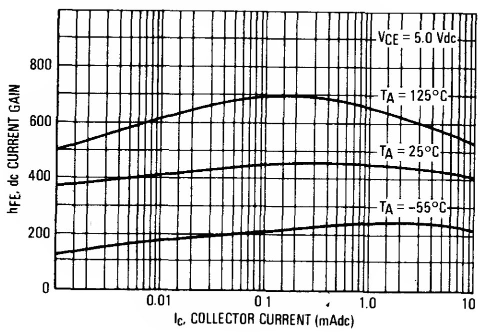


FIGURE 4b — TYPICAL CURRENT GAIN CHARACTERISTICS — 2N3799



2N3946
2N3947

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3.0 Vdc) (V_{CE} = 40 Vdc, V_{OB} = 3.0 Vdc, T_A = 150°C)		I_{CEX}	— —	0.010 15	μAdc
Base Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3.0 Vdc)		I_{BL}	—	.025	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3946 2N3947	h_{FE}	30 60	— —	—
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3946 2N3947		45 90	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3946 2N3947		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3946 2N3947		20 40	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	— —	0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	0.6 —	0.9 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3946 2N3947	f_T	250 300	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3946 2N3947	h_{ie}	0.5 2.0	6.0 12	kohms
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3946 2N3947	h_{re}	— —	10 20	X 10^{-4}
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3946 2N3947	h_{fe}	50 100	250 700	—
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3946 2N3947	h_{oe}	1.0 5.0	30 50	µmhos
Collector Base Time Constant (I_C = 10 mA, V_{CE} = 20 V, f = 31.8 MHz)		$r_{b'}C_c$	—	200	ps
Noise Figure (I_C = 100 µA, V_{CE} = 5.0 V, R_g = 1.0 kΩ, f = 10 Hz to 15.7 kHz)		NF	—	5.0	dB

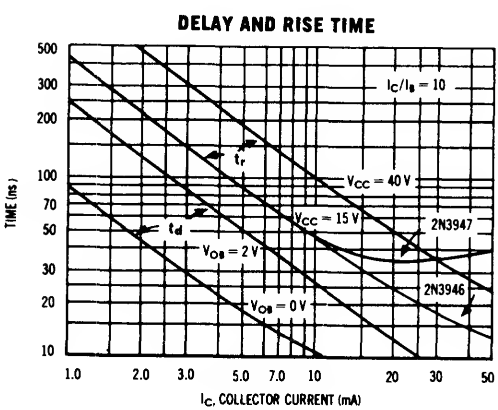
SWITCHING CHARACTERISTICS

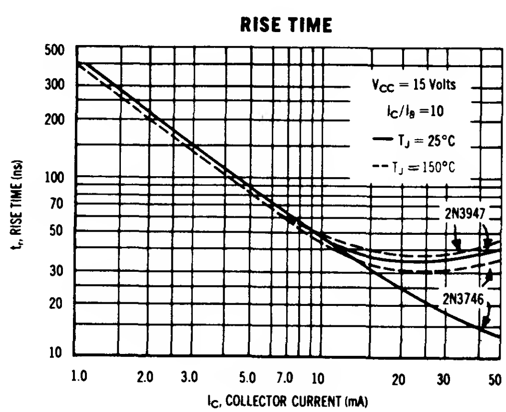
Characteristic	Conditions		Symbol	Min	Max	Unit
Delay Time	V_{CC} = 3.0 Vdc, V_{OB} = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mA		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	V_{CC} = 3.0 V, I_C = 10 mA, I_{B1} = I_{B2} = 1.0 mAdc	2N3946 2N3947	t_s	— —	300 375	ns
Fall Time			t_f	—	75	ns

(1) Pulse Test: PW ≤ 300 µs, Duty Cycle ≤ 2%.

TYPICAL SWITCHING CHARACTERISTICS

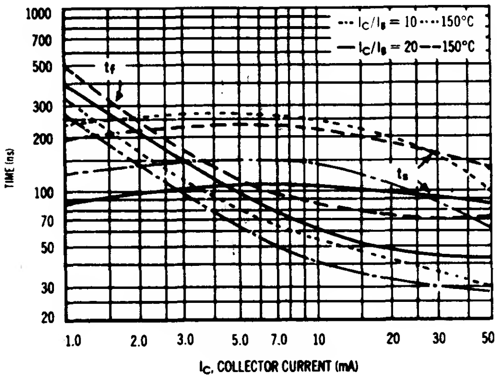
(T_A = 25°C unless otherwise noted)



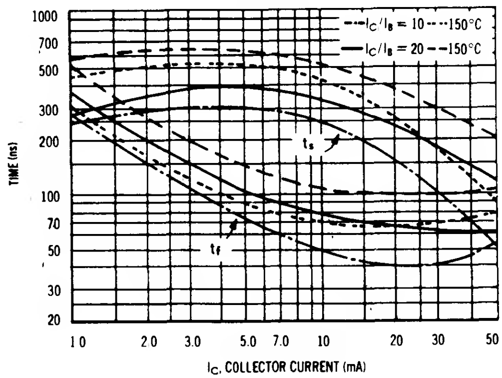


STORAGE AND FALL TIMES

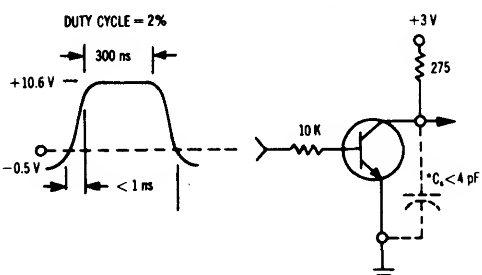
2N3946



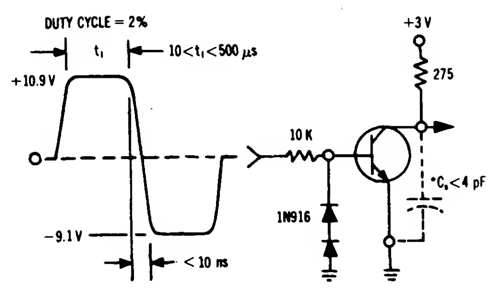
2N3947



TURN-ON TIME EQUIVALENT TEST CIRCUIT



TURN-OFF TIME EQUIVALENT TEST CIRCUIT

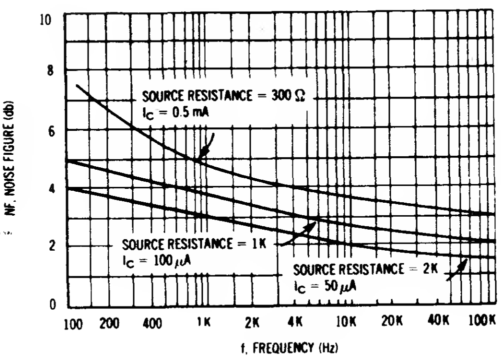


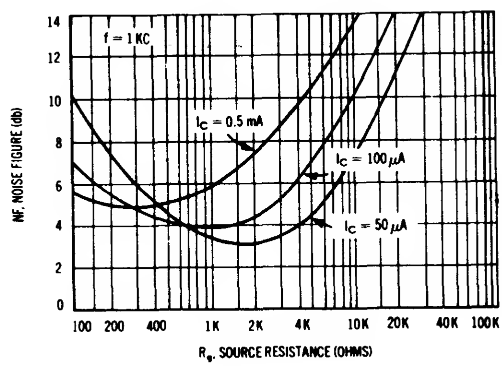
*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS

AUDIO SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5 V, T_A = 25°C

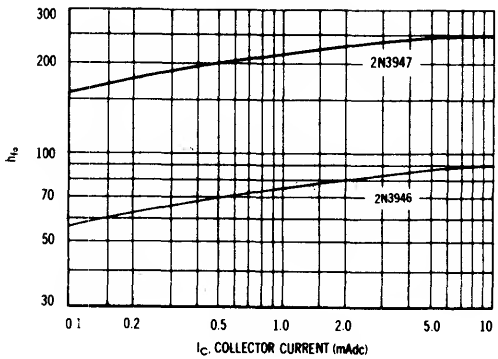




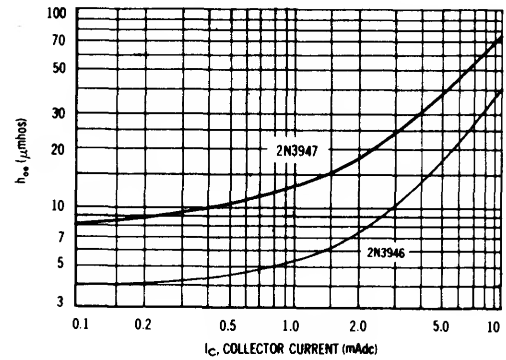
h PARAMETERS

$V_{CE} = 10$ V, $T_A = 25°C$, f = 1 Kc

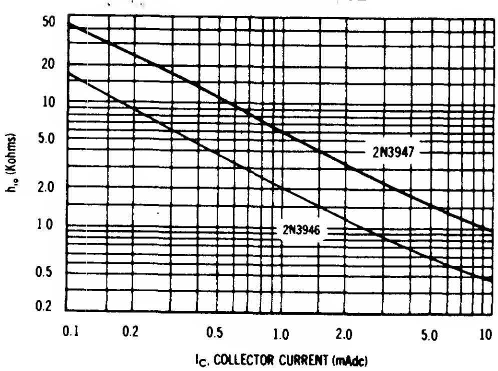
CURRENT GAIN



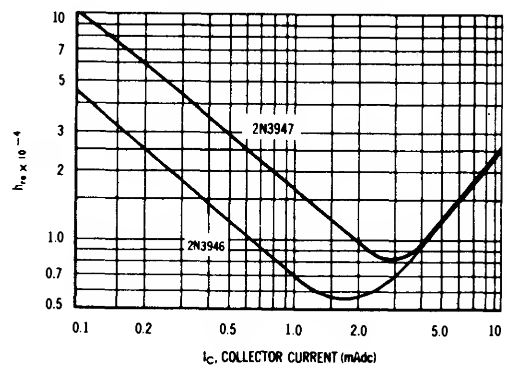
OUTPUT ADMITTANCE



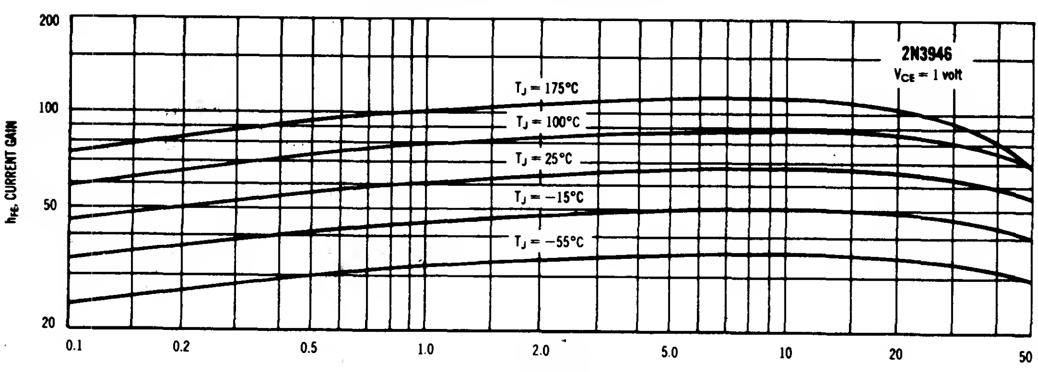
INPUT IMPEDANCE

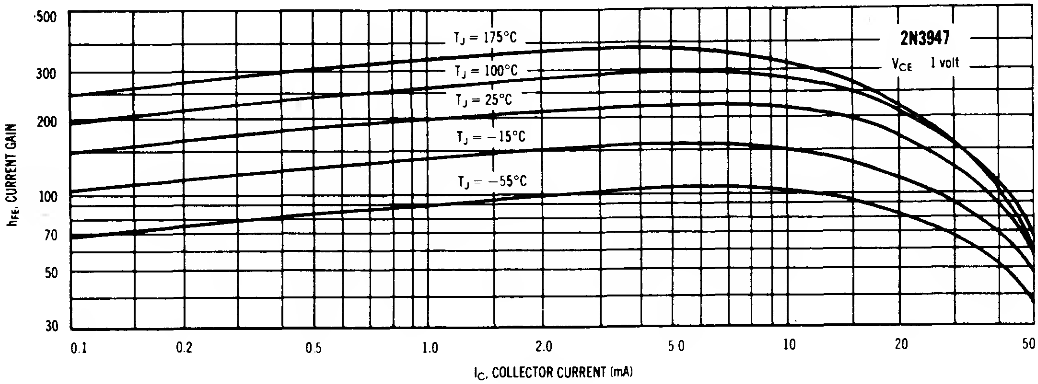


VOLTAGE FEEDBACK RATIO

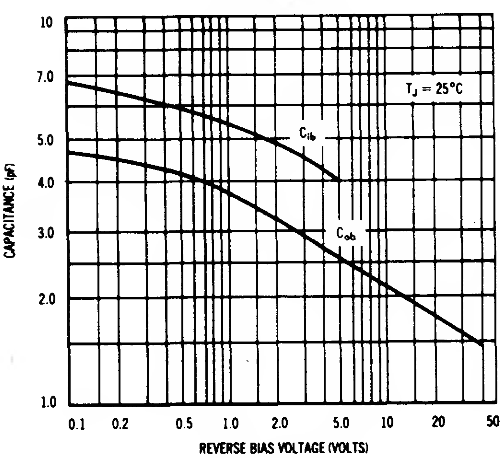


CURRENT GAIN CHARACTERISTICS

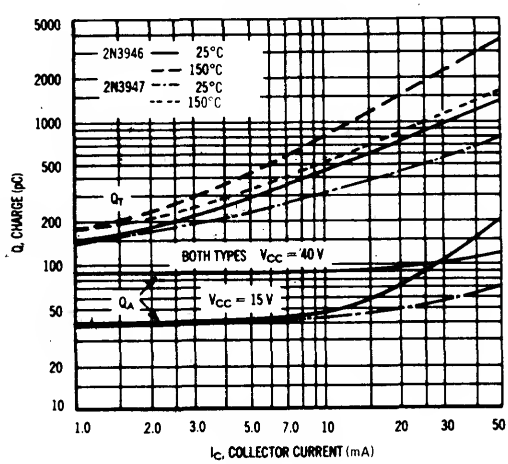




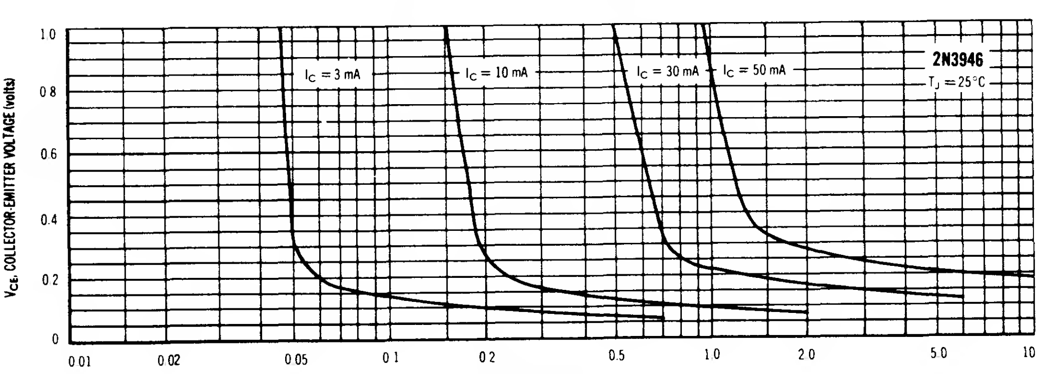
CAPACITANCE

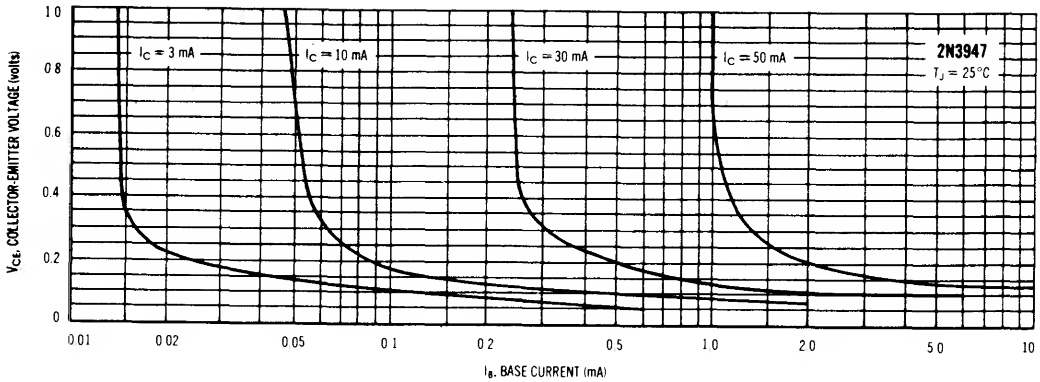


CHARGE DATA

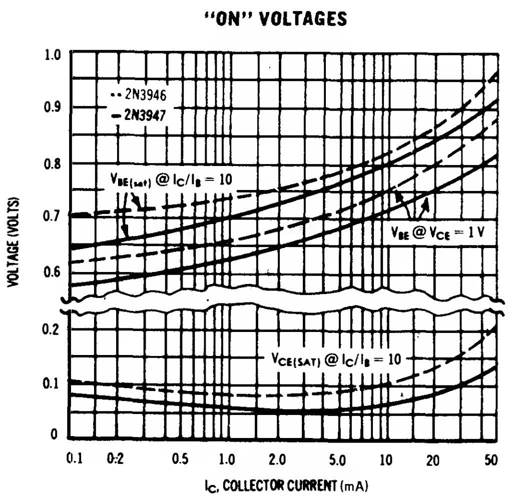


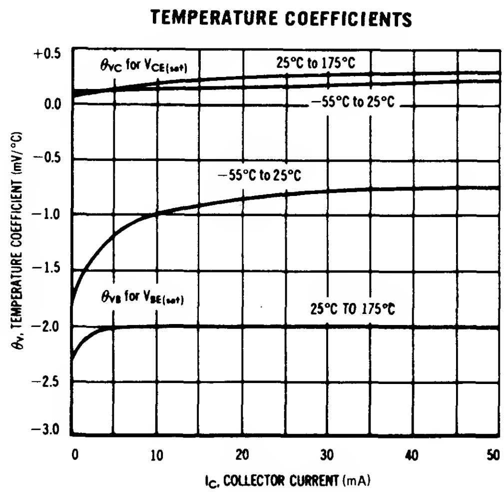
COLLECTOR SATURATION REGION




1.0
0.8
0.6
0.4
0.2
0
V_{CE}, COLLECTOR-EMITTER VOLTAGE (volts)
I_C = 3 mA
I_C = 10 mA
I_C = 30 mA
I_C = 50 mA
2N3947
T_J = 25°C
0.01
0.02
0.05
0.1
0.2
0.5
1.0
2.0
5.0
10
I_B, BASE CURRENT (mA)

4


"ON" VOLTAGES
1.0
0.9
0.8
0.7
0.6
0.2
0.1
0
VOLTAGE (VOLTS)
2N3946
2N3947
$V_{BE(sat)}$ @ I_C/I_B = 10
V_{BE} @ V_{CE} = 1 V
$V_{CE(SAT)}$ @ I_C/I_B = 10
0.1
0.2
0.5
1.0
2.0
5.0
10
20
50
I_C, COLLECTOR CURRENT (mA)


TEMPERATURE COEFFICIENTS
+0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
θ_V, TEMPERATURE COEFFICIENT (mV/°C)
θ_{VC} for $V_{CE(sat)}$
25°C to 175°C
−55°C to 25°C
−55°C to 25°C
θ_{VB} for $V_{BE(sat)}$
25°C TO 175°C
0
10
20
30
40
50
I_C, COLLECTOR CURRENT (mA)

2N3962
2N3963
2N3964
2N3965

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3962 2N3965	2N3964	2N3963	Unit
Collector-Emitter Voltage	V_{CEO}	60	45	80	V
Collector-Base Voltage	V_{CBO}	60	45	80	V
Emitter-Base Voltage	V_{EBO}		6.0		V
Collector Current — Continuous	I_C		200		mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		0.36 2.06		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		1.2 6.85		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

Refer to 2N3798 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 ma)	2N3962, 2N3965 2N3963 2N3964	$V_{(BR)CEO}$	60 80 45	— — —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μA)	2N3962, 2N3965 2N3963 2N3964	$V_{(BR)CES}$	60 80 45	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μA)	2N3962, 2N3965 2N3963 2N3964	$V_{(BR)CBO}$	60 80 45	— — —	Vdc
Emitter-Base Breakdown Voltage (I_C = 10 μA)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 50 V; 2N3964 = 40 V) (V_{CE} = 70 V)	 2N3965, 2N3962 2N3963	I_{CBO}	 — —	 10 10	nAdc
Collector Cutoff Current (V_{CE} = 50 V) (V_{CE} = 70 V) (V_{CE} = 40 V) (V_{CE} = 50 V)	 2N3962 2N3963 2N3964 2N3965	I_{CES}	 — — — —	 10 10 10 10	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 V)		I_{EBO}	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 μA, V_{CE} = 5.0 V)	 2N3962, 2N3963 2N3964, 2N3965	h_{FE}	 100 250	 300 500	—
(I_C = 100 μA, V_{CE} = 5.0 V)	2N3962, 2N3963 2N3964, 2N3965		100 250	— —	
(I_C = 1.0 mA, V_{CE} = 5.0)	2N3962, 2N3963 2N3964, 2N3965		100 250	450 600	
(I_C = 10 μA, V_{CE} = 5.0, T_A = −55°C)	2N3962, 2N3963 2N3964, 2N3965		40 100	— —	

4

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
(I_C = 1.0 mA, V_{CE} = 5.0 V, T_A = 100°C)	2N3962, 2N3963 2N3964, 2N3965		— —	600 800	
(I_C = 1.0 μA, V_{CE} = 5.0 V)	2N3962, 2N3963 2N3964, 2N3965		60 180	— —	
(I_C = 10 mA, V_{CE} = 5.0 V)	2N3962, 2N3963 2N3964, 2N3965		100 200	— —	
(I_C = 50 mA, V_{CE} = 5.0 V)	2N3962, 2N3963 2N3964, 2N3965		90 180	— —	
(I_C = 50 mA, V_{CE} = 5.0 V, T_A = −55°C)	2N3962, 2N3963 2N3964, 2N3965		45 90	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 50 mA, I_B = 5.0 mA)(1)		$V_{CE(sat)}$	— —	0.25 0.4	V V
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 50 mA, I_B = 5.0 mA)(1)		$V_{BE(sat)}$	— —	0.9 0.95	V V
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 V, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = 0.5 V, f = 1.0 MHz)		C_{ibo}	—	15	pF
Input Impedance (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	2N3962, 2N3963 2N3964, 2N3965	h_{ie}	2.5 6.0	17 20	kΩ
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 5.0, f = 1.0 kHz)		h_{re}	—	10	10^{-4}
Small-Signal Current Gain (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	2N3962, 2N3963 2N3964, 2N3965	h_{fe}	100 250	550 700	— —
Magnitude of Forward Current Transfer Ratio, Common-Emitter (I_C = 0.5 mA, V_{CE} = 5.0 V, f = 200 MHz)	2N3962, 2N3963 2N3964, 2N3965	$\|h_{fe}\|$	2.0 2.5	8.0 8.0	— —
Output Admittance (I_C = 1.0 mA, V_{CE} = 5.0, f = 1.0 kHz)	2N3962, 2N3963 2N3964, 2N3965	h_{oe}	5.0 5.0	40 50	μmhos
Noise Figure (I_C = 20 mA, V_{CE} = 5.0 V, BW = 15.7 kHz)	2N3962, 2N3963 2N3964, 2N3965	NF	— —	3 2	dB
(I_C = 20 μA, V_{CE} = 5.0 V, BW = 1.5 kHz, f = 10 kHz, R_S = 10 kΩ)	2N3962, 2N3963 2N3964, 2N3965		— —	3 2	
(I_C = 20 μA, V_{CE} = 5.0 V, BW = 150 Hz, f = 1.0 kHz, R_S = 10 kΩ)	2N3962, 2N3963 2N3964, 2N3965		— —	3 2	
(I_C = 20 μA, V_{CE} = 5.0 V, BW = 15 Hz, f = 100 Hz, R_S = 10 kΩ)	2N3962, 2N3963 2N3964, 2N3965		— —	10 4	
(I_C = 20 μA, V_{CE} = 5.0 V, BW = 2.0 Hz, f = 10 Hz, R_S = 10 kΩ)	2N3964, 2N3965		—	8	

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%.

2N4013
2N4014

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N4013	2N4014	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	50	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous — Peak	I_C	1.0 2.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 28.6		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.4 6.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	2N4014 2N4013	$V_{(BR)CEO}$	50 30	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	2N4014 2N4013	$V_{(BR)CES}$	80 50	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N4014 2N4013	$V_{(BR)CBO}$	80 50	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	2N4014 2N4013 2N4014 2N4013	I_{CBO}	— — — —	0.12 0.12 — —	1.7 1.7 120 120	μAdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{EB} = 0) (V_{CE} = 50 Vdc, V_{EB} = 0)	2N4014 2N4013	I_{CES}	— —	0.15 0.15	10 10	μAdc
ON CHARACTERISTICS(1)						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 300 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 800 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	 2N4014 2N4013 2N4014 2N4013	h_{FE}	30 60 30 40 35 20 20 25 25 30	— — — — — — — —	— 150 — — — — — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	2N4014 2N4013 2N4014 2N4013	$V_{CE(sat)}$	— — — —	0.17 0.17 0.19 0.19	0.25 0.25 0.26 0.20	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
(I_C = 300 mAdc, I_B = 30 mAdc)	2N4014 2N4013		— —	0.25 0.25	0.40 0.32	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N4014 2N4013		— —	0.30 0.30	0.52 0.42	
(I_C = 800 mAdc, I_B = 80 mAdc)	2N4014 2N4013		— —	0.43 0.43	0.80 0.65	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N4014 2N4013		— —	0.55 0.55	0.95 0.75	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 800 mAdc, I_B = 80 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	 — — — 0.8 — —	 — — — — — —	 0.76 0.86 1.1 1.1 1.5 1.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

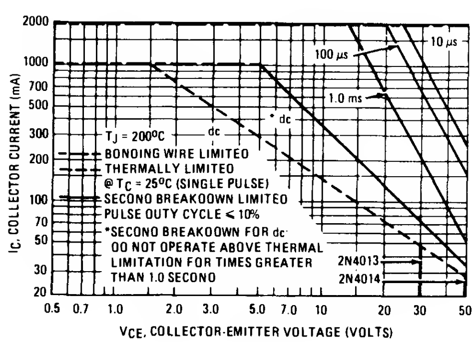
Characteristic		Symbol	Min	Typ	Max	Unit
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N4014 2N4013	C_{obo}	— —	— —	10 12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	—	55	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)	t_d	—	5.0	10	ns
Rise Time		t_r	—	15	30	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10) 2N4014 / 2N4013	t_s	—	30	50	ns
Fall Time		t_f	—	20 25	25 30	ns
Turn-On Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)	t_{on}	—	20	35	ns
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10) 2N4014 / 2N4013	t_{off}	—	50	60	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.
(2) f_T = $|h_{fe}| \cdot f_{test}$.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

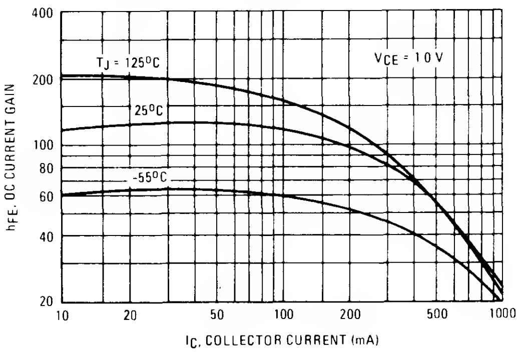


FIGURE 3 – "ON" VOLTAGES

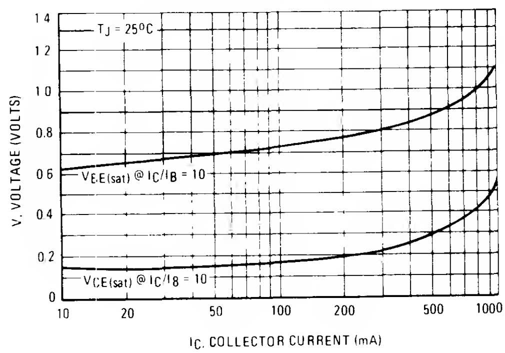


FIGURE 4 – COLLECTOR SATURATION REGION

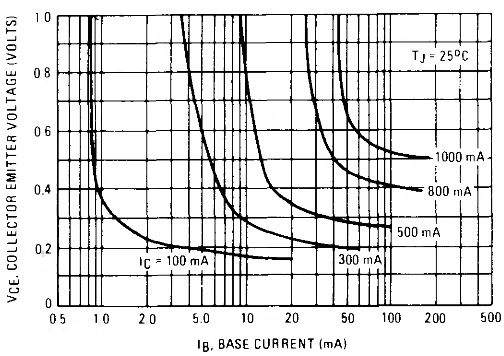
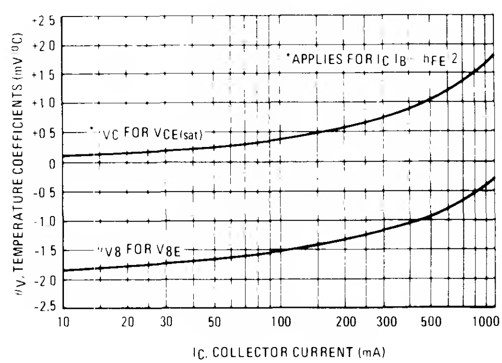


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

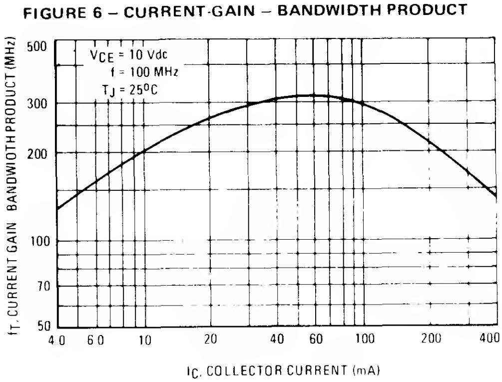


FIGURE 7 – CAPACITANCE

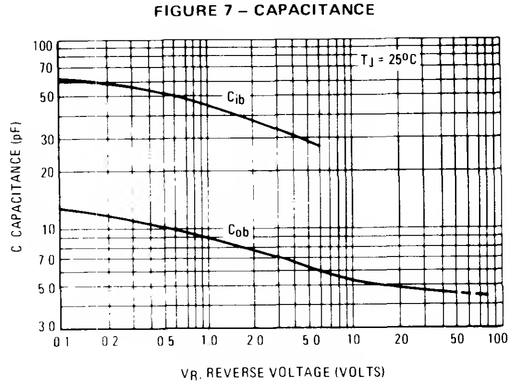


FIGURE 8 – TURN-ON TIME

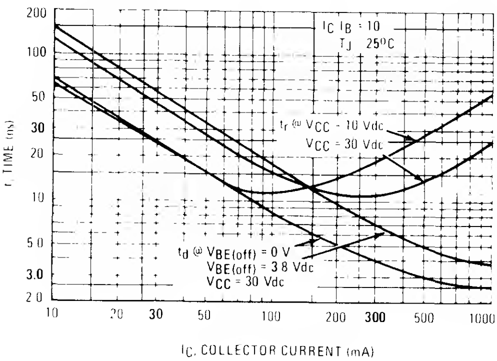


FIGURE 9 – TURN-OFF TIME

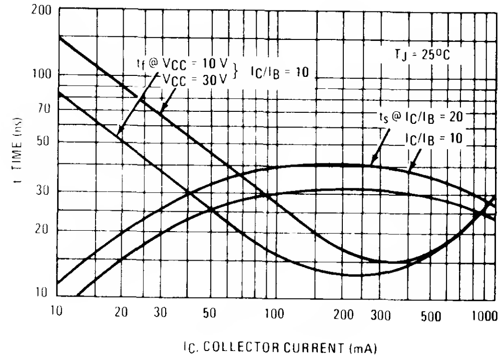
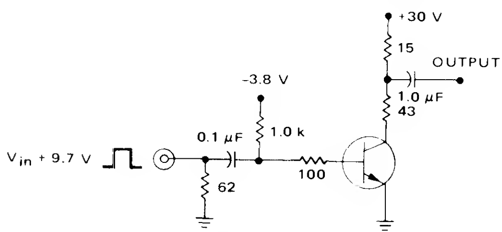
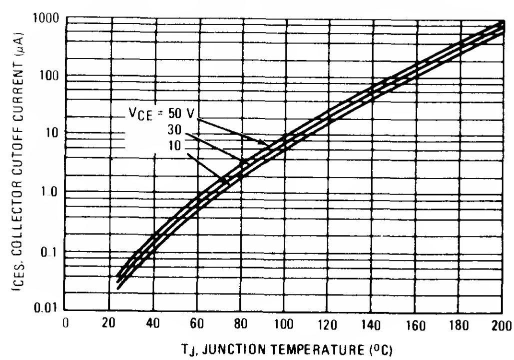


FIGURE 10 – SWITCHING TIME TEST CIRCUIT



$t_r \leq 1.0$ ns
P.W. $\geq$ 200 ns
Duty Cycle $\leq$ 2.0%
Generator Source Impedance = 50 Ω
Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope: Tektronix 661 Sampling Scope

FIGURE 11 – COLLECTOR CUTOFF CURRENT



MAXIMUM RATINGS

Rating	Symbol	2N4026/28 2N4030/32	2N4027/29 2N4031/33	Unit
Collector-Emitter Voltage(1)	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	5.0	Vdc
		2N4026-2N4029	2N4030-2N4033	
Collector Current — Continuous	I_C	1.0	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	.5 2.85	1.25 7.15	W mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.0 11.4	7.0 40	W mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Lead or Terminal Temperature(2)	T_L	+300		°C

(1) Applicable 0 to 10 mA
(2) Measured at a distance not less than 1/16" from seated surface (or case) for 60 Sec.

THERMAL CHARACTERISTICS

Characteristic	Symbol	TO-18	TO-39	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	40	20	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	280	140	°C/W

2N4026 thru 2N4033

2N4026–2N4029
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

JAN, JTX, TXV AVAILABLE IN 2N4033

2N4030–2N4033
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N4405 for graphs.

4

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	2N4026,28,30,32 2N4027,29,31,33	$V_{(BR)CEO}$	60 80	— —	V
Collector-Base Breakdown Voltage ($I_C = 10\ \mu A$)	2N4026,28,30,32 2N4027,29,31,33	$V_{(BR)CBO}$	60 80	— —	V
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$)		$V_{(BR)EBO}$	5.0	—	V
Collector Cutoff Current ($V_{CB} = 50$ V) ($V_{CB} = 60$ V) ($V_{CB} = 50$ V, $T_A = 150°C$) ($V_{CB} = 60$ V, $T_A = 150°C$)	2N4026,28,30,32 2N4027,29,31,33 2N4026,28,30,32 2N4027,29,31,33	I_{CBO}	— — — —	50 50 50 50	nA μA
Emitter Cutoff Current ($V_{EB} = 5.0$ V)		I_{EBO}	—	10	μA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mA, $V_{CE} = 5.0$ V, @ −55°C)	2N4026,27,30,31 2N4028,29,32,33	h_{FE}	15 40	— —	—
($I_C = 100\ \mu A$, $V_{CE} = 5.0$ V)	2N4026,27,30,31 2N4028,29,32,33		30 75	— —	
($I_C = 100$ mA, $V_{CE} = 5.0$ V)	2N4026,27,30,31 2N4028,29,32,33		40 100	120 300	
($I_C = 500$ mA, $V_{CE} = 5.0$ V)	2N4026,27,30,31 2N4028,29,32,33		25 70	— —	
($I_C = 1.0$ A, $V_{CE} = 5.0$ V)	2N4026,30 2N4027,31		15 10	— —	
($I_C = 1.0$ A, $V_{CE} = 5.0$ V)	2N4028,32 2N4029,33		40 25	— —	

2N4026 thru 2N4033

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			V
(I_C = 150 mA, I_B = 15 mA)			—	0.15	
(I_C = 500 mA, I_B = 50 mA)			—	0.15	
(I_C = 1.0 A, I_B = 100 mA)	2N4026,28,30,32		—	1.0	
Base-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA)		$V_{BE(sat)}$	—	0.9	V
Base-Emitter On Voltage		$V_{BE(on)}$			V
(I_C = 1.0 A, V_{CE} = 1.0 V)	2N4026,28,30,32		—	1.2	
(I_C = 500 mA, V_{CE} = 0.5 V)			—	1.1	
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CE} = 10 V, f = 1.0 MHz)		C_{obo}	—	20	pF
Input Capacitance (V_{EB} = 0.5 V, f = 1.0 MHz)		C_{ibo}	—	110	pF
Small Signal Current Gain (I_C = 50 mA, V_{CE} = 10 V, f = 100 MHz)		h_{fe}	1.0	4.0	—
SWITCHING CHARACTERISTICS					
Storage Time (I_C = 500 mA, I_{B1} = I_{B2} = 50 mA)		t_s	—	350	ns
Turn-On Time (I_C = 500 mA, I_{B1} = 50 mA)		t_{on}	—	100	ns
Turn-Off Time (I_C = 500 mA, I_{B1} = I_{B2} = 50 mA)		t_{off}	—	50	ns

(3) Pulse Width = 300 μs, Duty Cycle 1.0%.

MAXIMUM RATINGS

Rating	Symbol	2N4036	2N4037	Unit
Collector-Emitter Voltage	V_{CEO}	65	40 (sus)(1)	Vdc
Collector-Base Voltage	V_{CBO}	90	60	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	7.0	Vdc
Base Current	I_B	0.5		Adc
Collector Current — Continuous	I_C	1.0		Adc
Continuous Power Dissipation at or Below $T_C = 25°C$ Linear Derating Factor	P_D	5.0 28.6	1.0 5.72	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Lead Temperature 1/16″ from Case for 10 Seconds	T_L	230		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N4036	2N4037	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	—	°C/W

(1) Must not be tested on a curve tracer.

2N4036
2N4037

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

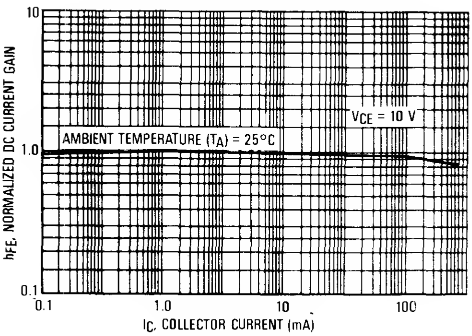
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ($I_C = 100$ mAdc, $I_B = 0$)	2N4036 2N4037	$V_{CEO(sus)}$	65 40	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mA dc)	2N4037	$V_{(BR)CBO}$	60	—	Vdc
Collector Cutoff Current ($V_{CE} = 85$ V, $V_{BE} = 1.5$ V) ($V_{CE} = 30$ V, $V_{BE} = 1.5$ V, $T_C = 150°C$)	2N4036	I_{CEX}	—	100 0.1	mAdc
Collector Cutoff Current ($V_{CB} = 90$ V, $I_E = 0$) ($V_{CB} = 60$ V, $I_E = 0$)	2N4036 2N4037	I_{CBO}	—	100 0.25	μAdc
Emitter Cutoff Current ($V_{BE} = 7.0$ Vdc, $I_C = 0$) ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	2N4036 2N4037	I_{EBO}	— —	10.0 1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 150$ mAdc, $V_{CE} = 2.0$ V) ($I_C = 0.1$ mAdc, $V_{CE} = 10$ V) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ V)	2N4036 2N4036 2N4037	h_{FE}	20 20 15	200 — —	—
($I_C = 150$ mAdc, $V_{CE} = 10$ V)	2N4036 2N4037		40 50	140 250	
($I_C = 500$ mAdc, $V_{CE} = 10$ V)	2N4036		20	—	
Collector-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA)	2N4036 2N4037	$V_{CE(sat)}$		0.65 1.4	V
Base-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA)	2N4036	$V_{BE(sat)}$		1.4	V
Base-Emitter On Voltage ($I_C = 150$ mA, $V_{CE} = 10$ V)	2N4037	$V_{BE(on)}$		1.5	V
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)	2N4037	C_{cb}	—	30	pF
Current Gain — High Frequency ($I_C = 50$ mA, $V_{CE} = 10$ V, f = 20 MHz)	2N4036 2N4037	$\|h_{fe}\|$	3.0 3.0	— 10.0	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

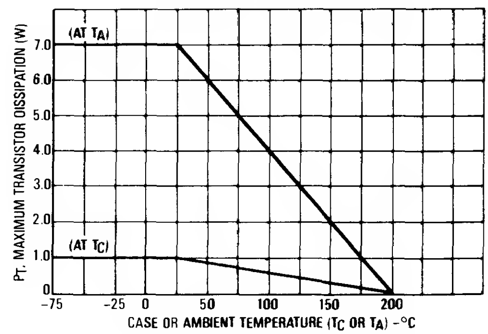
Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Rise Time (I_{B1} = 15 mA)	2N4036	t_r	—	70	ns
Storage Time (I_{B2} = 15 mA)	2N4036	t_s	—	600	ns
Fall Time (I_{B2} = 15 mA)	2N4036	t_f	—	100	ns
Turn-On Time (I_{B1} = I_{B2})	2N4036	t_{on}	—	110	ns
Turn-Off Time (I_{B1} = I_{B2})	2N4036	t_{off}	—	700	ns

4

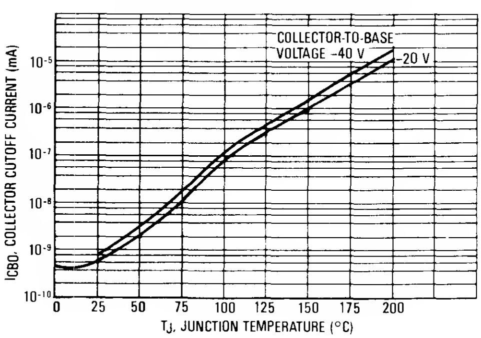
CURRENT GAIN CHARACTERISTICS
versus COLLECTOR-EMITTER VOLTAGE



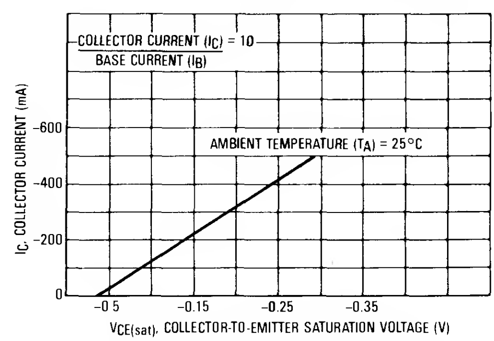
DISSIPATION DERATING CURVE



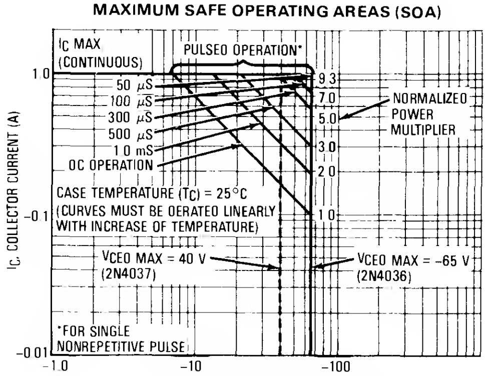
TYPICAL COLLECTOR-CUTOFF CURRENT
versus JUNCTION TEMPERATURE



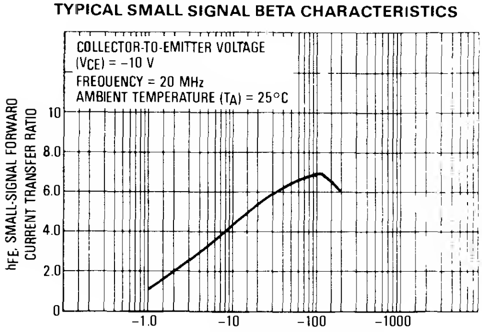
TYPICAL SATURATION-VOLTAGE CHARACTERISTICS



MAXIMUM SAFE OPERATING AREAS (SOA)



TYPICAL SMALL SIGNAL BETA CHARACTERISTICS



2N4208
2N4209

JAN TX, TXV AVAILABLE
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N4208	2N4209	Unit
Collector-Emitter Voltage	V_{CEO}	12	15	Vdc
Collector-Base Voltage	V_{CBO}	12	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	50–200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.30–0.36 1.72–2.06		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.70–1.2 4.0–6.9		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 3.0$ mAdc, $I_B = 0$)	2N4208 2N4209	$V_{(BR)CEO}$	12 15	— —	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu$Adc, $V_{BE} = 0$)	2N4208 2N4209	$V_{(BR)CES}$	12 15	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	2N4208 2N4209	$V_{(BR)CBO}$	12 15	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	4.5	5.9	—	Vdc
Collector Cutoff Current ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 8.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$, $T_A = 125°C$) ($V_{CE} = 8.0$ Vdc, $V_{BE} = 0$, $T_A = 125°C$)	2N4208 2N4209 2N4208 2N4209	I_{CES}	— — — —	— — — —	10 10 5.0 5.0	nAdc μAdc
Base Current ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 8.0$ Vdc, $V_{BE} = 0$)	2N4208 2N4209	I_B	— —	— —	1.0 1.0	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 0.5$ Vdc)	 2N4208 2N4209	h_{FE}	 15 35	 — —	 — —	—
($I_C = 10$ mAdc, $V_{CE} = 0.3$ Vdc)	2N4208 2N4209		30 50	— —	120 120	
($I_C = 10$ mAdc, $V_{CE} = 0.3$ Vdc, $T_A = -55°C$)	2N4208 2N4209		12 20	— —	— —	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	2N4208 2N4209		30 40	— —	— —	
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)	 2N4208 2N4209	$V_{CE(sat)}$	 — —	 — —	 0.13 0.15	Vdc
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	2N4208 2N4209		— —	— —	0.15 0.18	
($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)(1)	2N4208 2N4209		— —	— —	0.5 0.6	
Base-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)(1)		$V_{BE(sat)}$	 — 0.75 —	 0.7 0.86 1.1	 0.8 0.90 1.5	Vdc

4

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS							
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		2N4208 2N4209	f_T	700 850	1000 1100	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)			C_{obo}	—	2.0	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)			C_{ibo}	—	2.0	3.5	pF
SWITCHING CHARACTERISTICS							
Turn-On Time	(V_{CC} = 1.5 Vdc, V_{BE} = 0, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_{on}	—	10	15	ns
Delay Time			t_d	—	5.0	10	ns
Rise Time			t_r	—	5.0	15	ns
Turn-Off Time	(V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	2N4208 2N4209	t_{off}	— —	12 16	15 20	ns
Storage Time		2N4208 2N4209	t_s	— —	12 17	15 20	ns
Fall Time		2N4208 2N4209	t_f	—	6.0 8.0	10 10	ns
Storage Time (I_C ≈ 10 mAdc, I_{B1} ≈ 10 mAdc, I_{B2} ≈ 10 mAdc)		2N4208 2N4209	t_s	— —	— —	15 20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N4234
2N4235
2N4236

CASE 079-02, STYLE 1
TO-39 (TO-205AD)

POWER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N4234	2N4235	2N4236	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CBO}	40	60	80	Vdc
Emitter-Base Voltage	V_{EBO}		7.0		Vdc
Base Current	I_B		0.2		Vdc
Collector Current — Continuous	I_C		1.0 3.0*		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		1.0 5.7		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		6.0 34		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	29	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	2N4234 2N4235 2N4236	$V_{CEO(sus)}$	40 60 80	— — —	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0) (V_{CE} = 40 Vdc, I_B = 0) (V_{CE} = 60 Vdc, I_B = 0)	 2N4234 2N4235 2N4236	I_{CEO}	 — — —	 1.0 1.0 1.0	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 1.5 Vdc) (V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc) (V_{CE} = 80 Vdc, V_{BE} = 1.5 Vdc) (V_{CE} = 30 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C) (V_{CE} = 40 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C) (V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	 2N4234 2N4235 2N4236 2N4234 2N4235 2N4236	I_{CEX}	 — — — — — —	 0.1 0.1 0.1 1.0 1.0 1.0	mAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 2N4234 2N4235 2N4236	I_{CBO}	 — — —	 0.1 0.1 0.1	mAdc
Emitter Cutoff Current (V_{BE} = 7 Vdc, I_C = 0)		I_{EBO}	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		h_{FE}	 40 30 20 10	 — 150 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 125 mAdc)		$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		V_{BE}	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	3.0	—	MHz

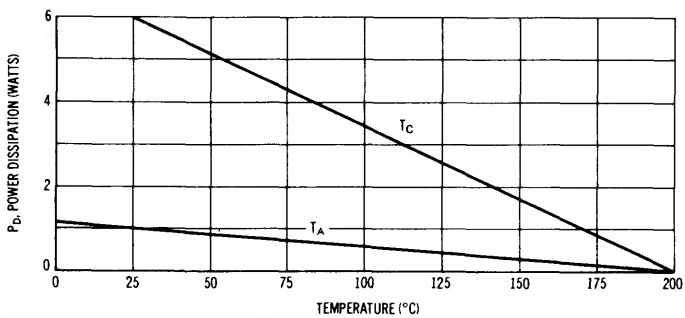
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	100	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	25	—	—

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.
*Indicates Data in addition to JEDEC Requirements.

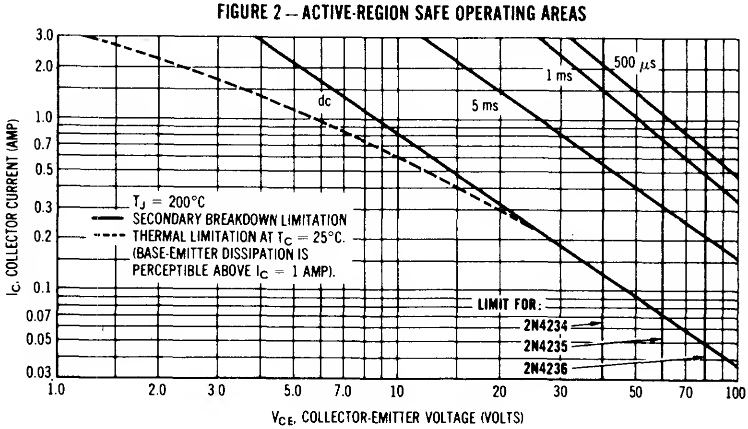
4

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
All limits are applicable and must be observed.

FIGURE 2 — ACTIVE-REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE

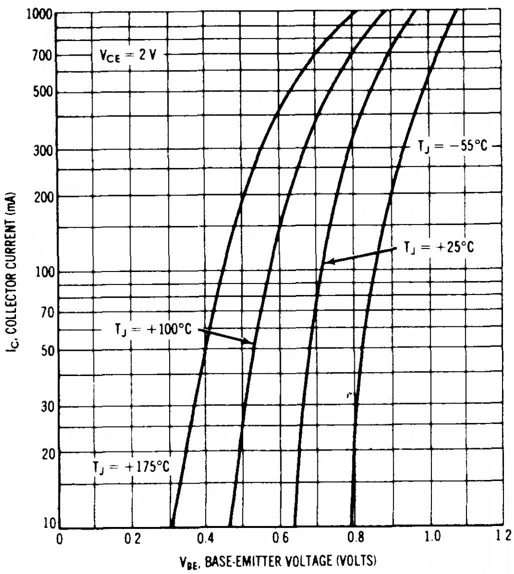
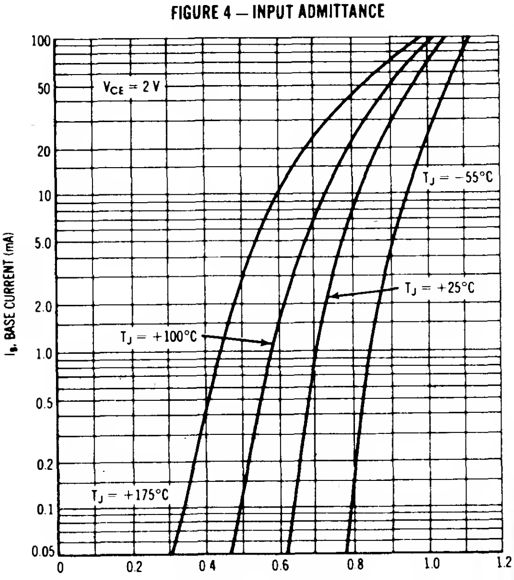


FIGURE 4 — INPUT ADMITTANCE



"OFF" REGION CHARACTERISTICS

FIGURE 5 — TRANSCONDUCTANCE

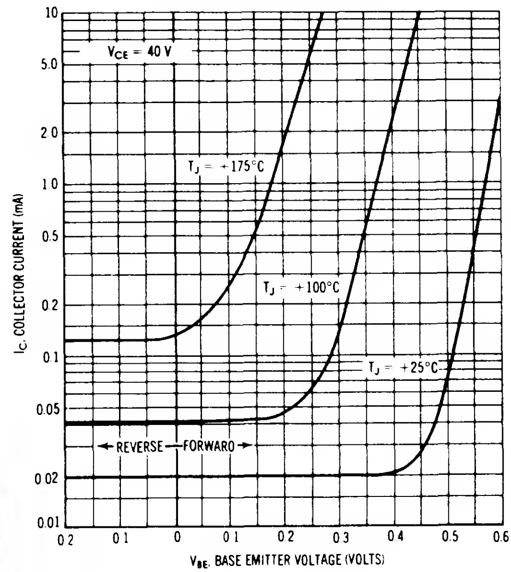
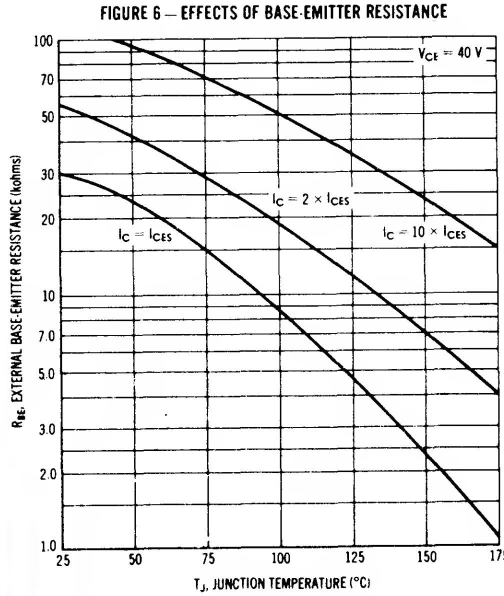
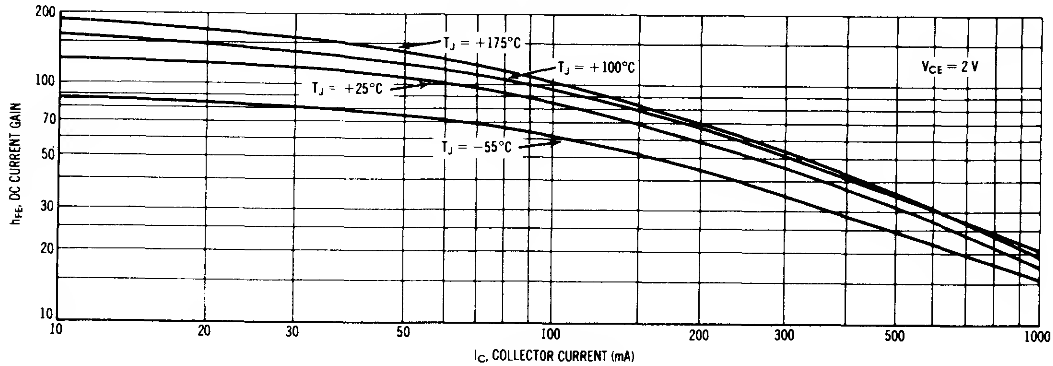


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE



4

FIGURE 7 — CURRENT GAIN



SATURATION REGION CHARACTERISTICS

FIGURE 8 — COLLECTOR SATURATION REGION

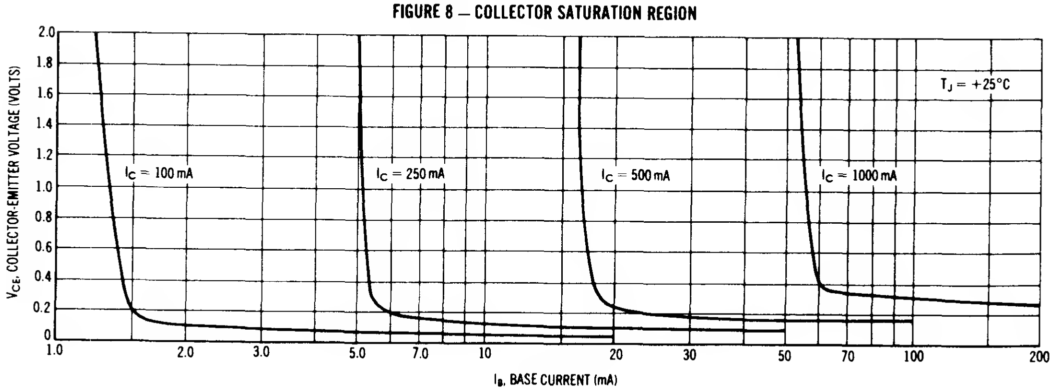


FIGURE 9 — "ON" VOLTAGES

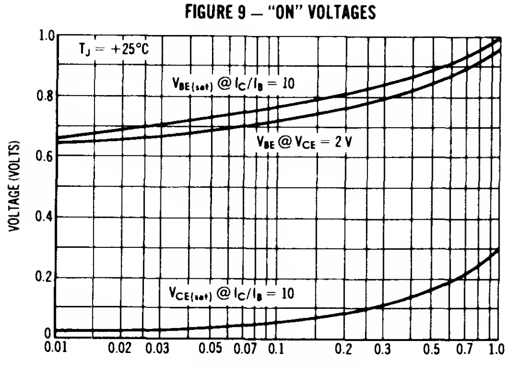
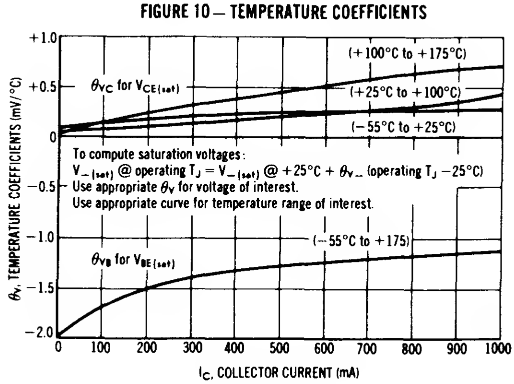


FIGURE 10 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 11 — TURN-ON TIME

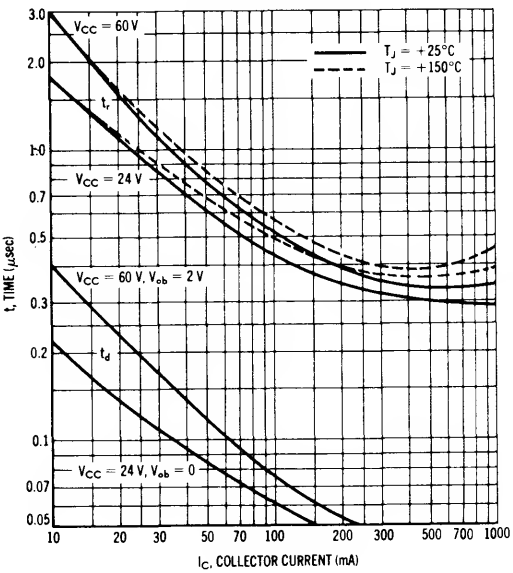


FIGURE 13 — CAPACITANCE

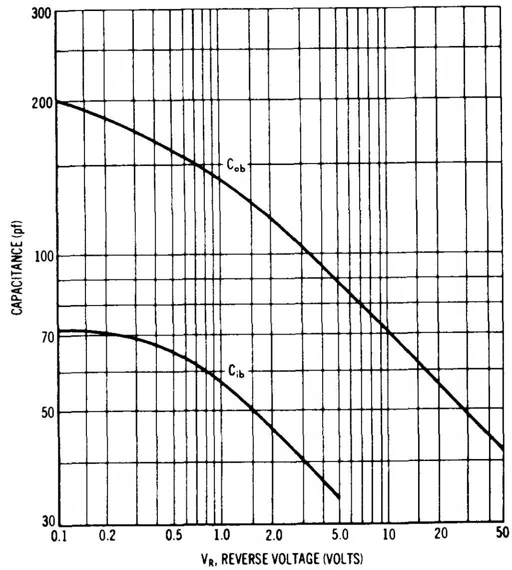


FIGURE 12 — STORAGE TIME

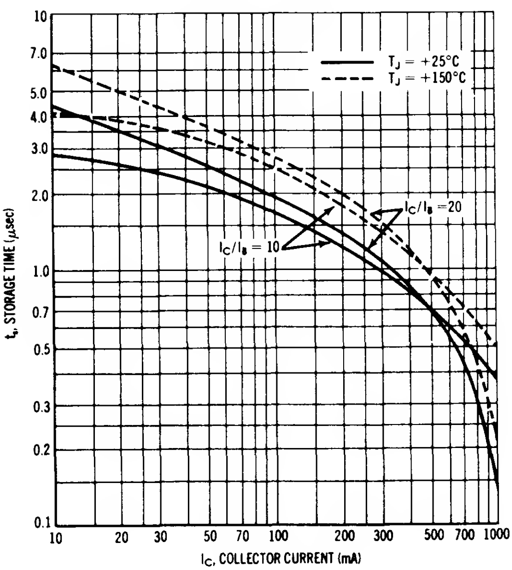
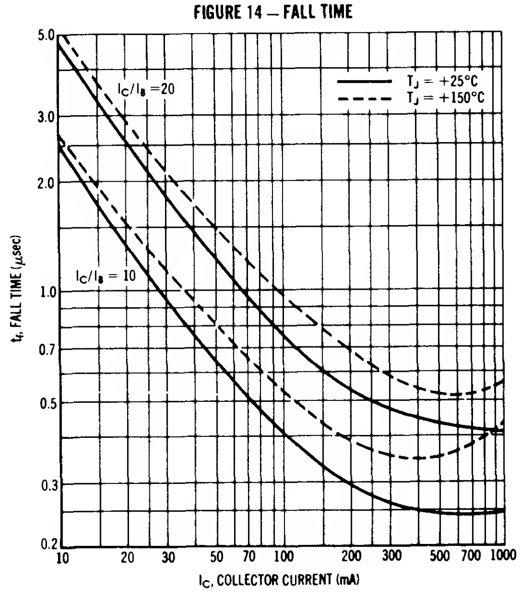


FIGURE 14 — FALL TIME



2N4237
2N4238
2N4239

CASE 079-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N4237	2N4238	2N4239	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CBO}	50	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Base Current	I_B	500			Vdc
Collector Current — Continuous	I_C	1.0 3.0*			Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.3			Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	6.0 34			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

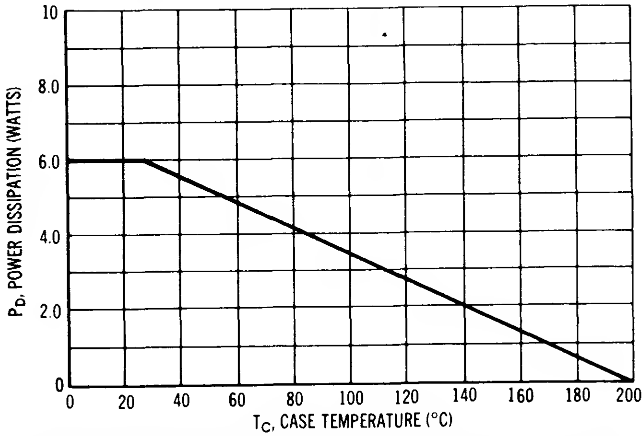
Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	$R_{\theta JC}$	29	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	2N4237 2N4238 2N4239	$V_{CEO(sus)}$	40 60 80	— — —	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{EB} = 1.5 Vdc) (V_{CE} = 80 Vdc, V_{EB} = 1.5 Vdc) (V_{CE} = 100 Vdc, V_{EB} = 1.5 Vdc) (V_{CE} = 30 Vdc, V_{EB} = 1.5 Vdc, T_C = 150°C) (V_{CE} = 50 Vdc, V_{EB} = 1.5 Vdc, T_C = 150°C) (V_{CE} = 70 Vdc, V_{EB} = 1.5 Vdc, T_C = 150°C)	2N4237 2N4238 2N4239 2N4237 2N4238 2N4239	I_{CEX}	— — — — — —	0.1 0.1 0.1 1.0 1.0 1.0	mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CBO}, I_E = 0) (V_{CE} = Rated V_{CEO}, I_B = 0)		I_{CBO}	— —	0.1 .07	mAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)		I_{EBO}	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		h_{FE}	30 30 30 15	— 150 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{CE(sat)}$	— —	0.3 0.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{BE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage(1) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = 0.1 MHz)		C_{obo}	—	100	pF
Small Signal Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	30	—	—
Current Gain — High Frequency (V_{CE} = 10 V, I_C = 100 mA, f = 1 MHz)		$\|h_{fe}\|$	1.0	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.
*Indicates Data in addition to JEDEC Requirements.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

SWITCHING CHARACTERISTICS

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

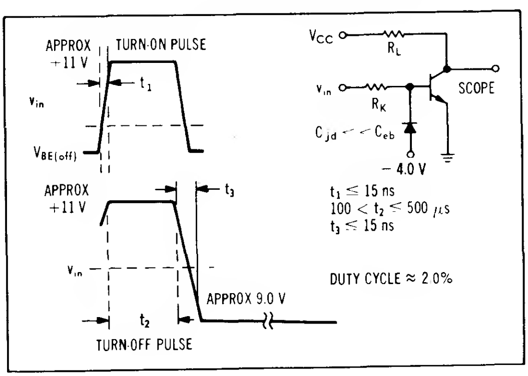


FIGURE 3 — TURN-ON TIME

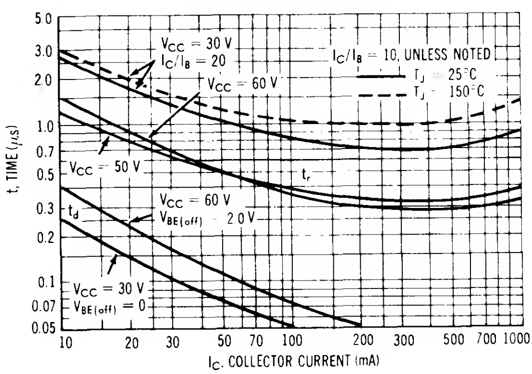


FIGURE 4 — THERMAL RESPONSE

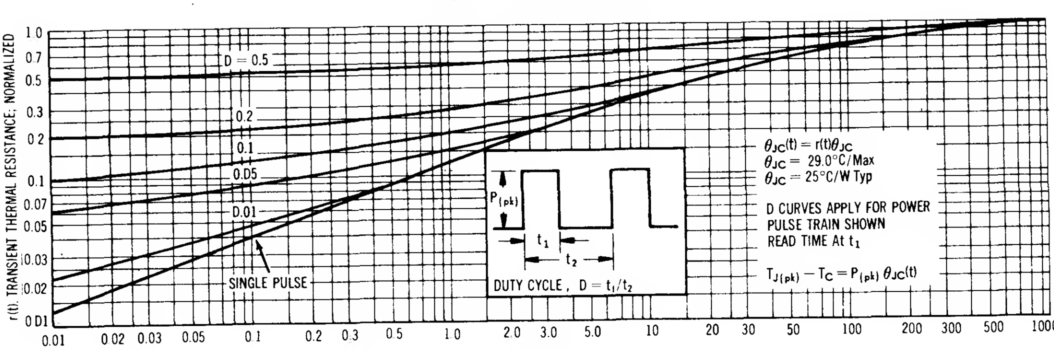


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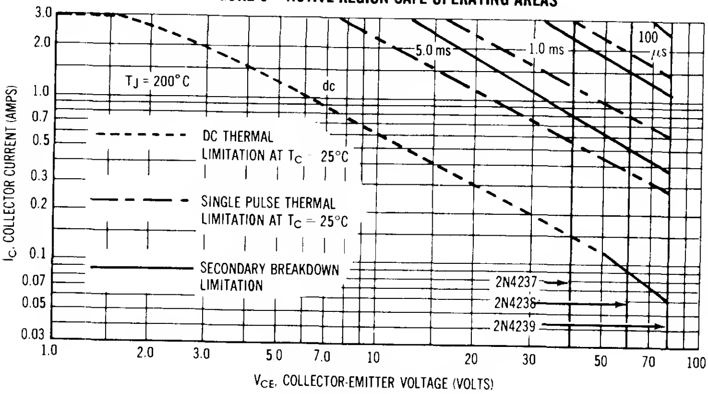
FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

For this particular transistor family the thermal curves are the limiting design values, except for a small portion of the dc curve. The pulse secondary breakdown curves are shown for information only.

FIGURE 6 — STORAGE TIME

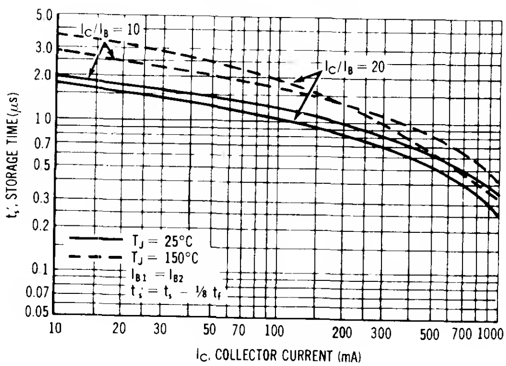
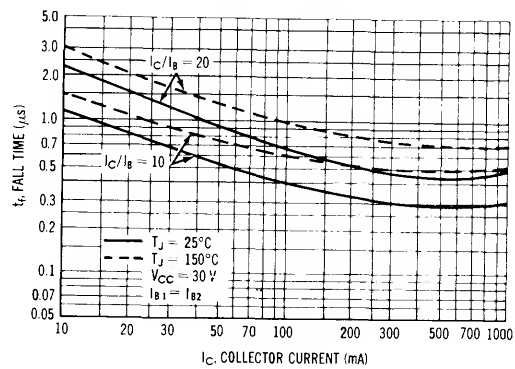


FIGURE 7 — FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 8 — CURRENT GAIN

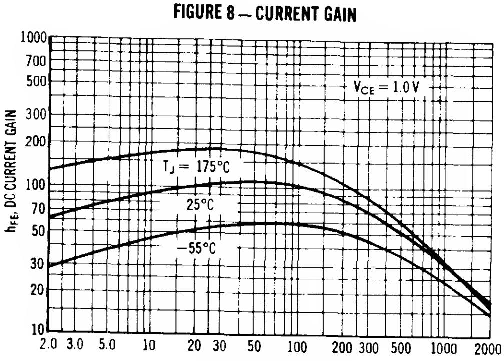


FIGURE 9 — COLLECTOR SATURATION REGION

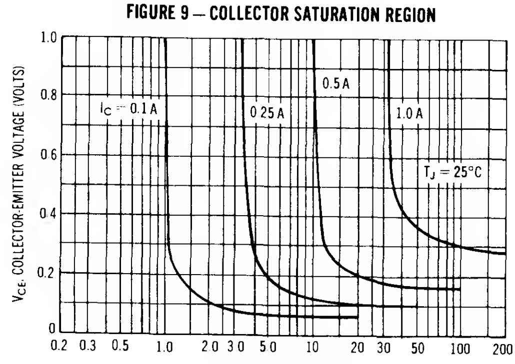


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

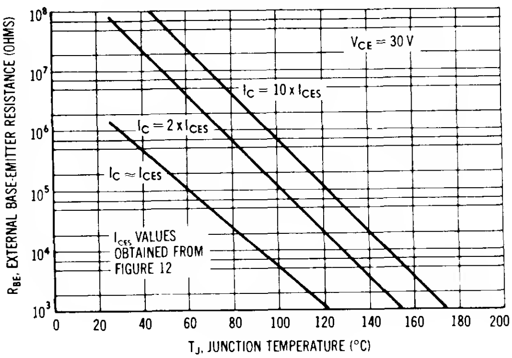


FIGURE 11 — "ON" VOLTAGE

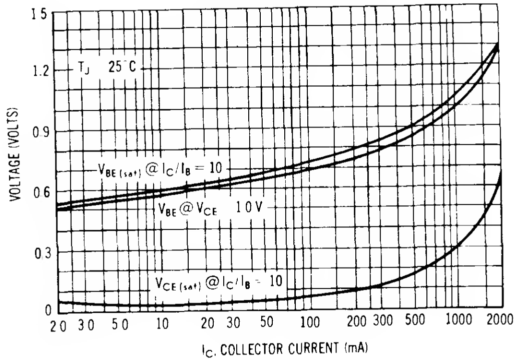


FIGURE 12 — COLLECTOR CUTOFF REGION

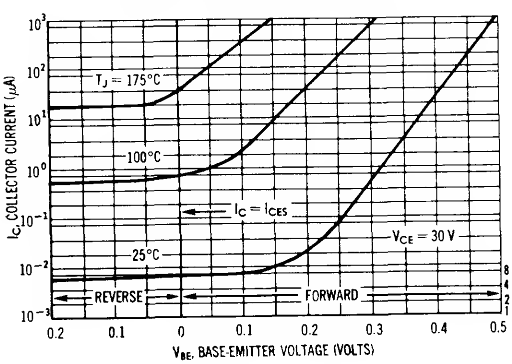
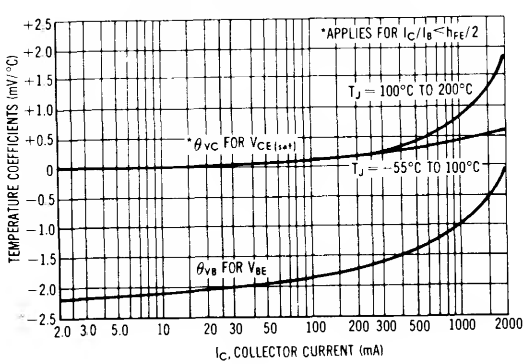


FIGURE 13 — TEMPERATURE COEFFICIENTS



4

2N4260
2N4261

2N4261 JAN, JTX AVAILABLE
CASE 20, STYLE 10
TO-72

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_E = 0$)		$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.5	—	Vdc
Collector Cutoff Current ($V_{CE} = 10$ Vdc, $V_{BE(off)} = 2.0$ Vdc) ($V_{CE} = 10$ Vdc, $V_{BE(off)} = 2.0$ Vdc, $T_A = 150°C$) ($V_{CE} = 10$ Vdc, $V_{EB(on)} = 0.4$ Vdc)		I_{CEX}	 — — —	 0.005 5.0 0.05	μAdc
Base Cutoff Current ($V_{CE} = 10$ Vdc, $V_{BE(off)} = 2.0$ Vdc)		I_{BL}	—	0.005	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 2.0$ Vdc)		h_{FE}	 25 30 20	 — 150 —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.15 0.35	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	 — —	 0.8 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 4.0$ Vdc, f = 100 MHz) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	 2N4260 2N4261 2N4260 2N4261	f_T	 1200 1500 1600 2000	 — — — —	MHz
Output Capacitance ($V_{CB} = 4.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	2.5	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	2.5	pF
Current Gain — High Frequency ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	2N4260 2N4261	$\|h_{fe}\|$	16 20	— —	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector Base Time Constant		$rb'C_C$			ps
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 31.8 MHz)	2N4260		—	35	
	2N4261		—	60	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 31.8 MHz)	2N4260		—	30	
	2N4261		—	50	

SWITCHING CHARACTERISTICS

Characteristic	Symbol	Typical Performance (v_{out} = 1.0 V) @ 10 mA	Typical Performance (v_{out} = 1.0 V) @ 30 mA	Unit
Rise Time	t_r	0.5	0.9	ns
Fall Time	t_f	1.0	1.2	ns
Turn-On Time	$t_{on(delay)}$	1.0	1.2	ns
Turn-Off Delay Time	$t_{off(delay)}$	1.0	1.2	ns

4

FIGURE 1 — DC CURRENT GAIN

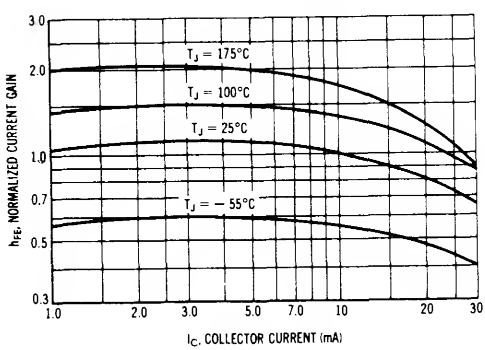


FIGURE 2 — COLLECTOR SATURATION REGION

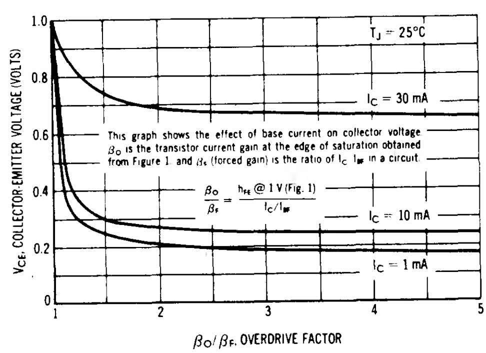


FIGURE 3 — "ON" VOLTAGES

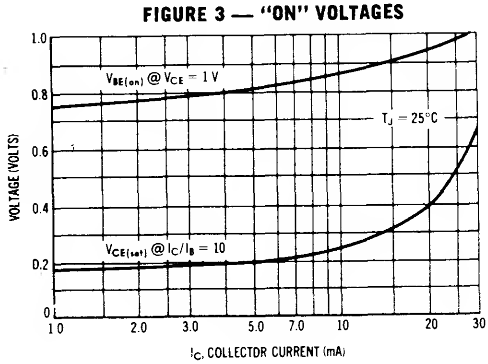


FIGURE 4 — TEMPERATURE COEFFICIENTS

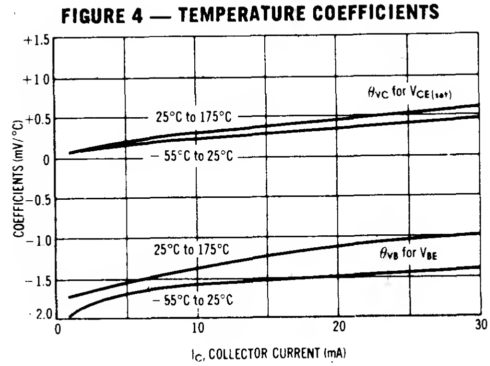


FIGURE 5 — CURRENT-GAIN — BANDWIDTH PRODUCT

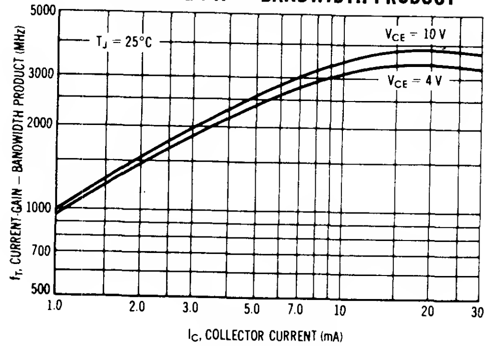


FIGURE 6 — COLLECTOR-BASE TIME CONSTANT

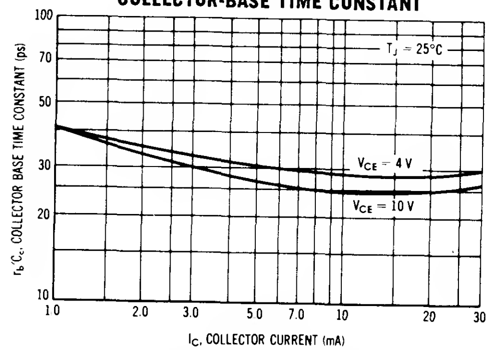
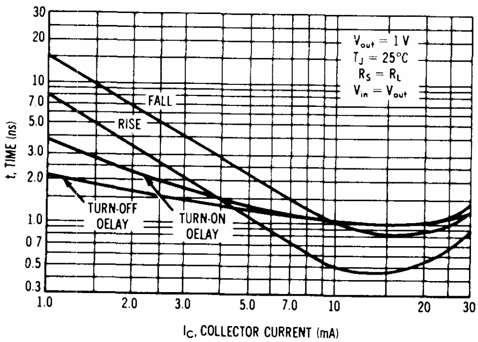
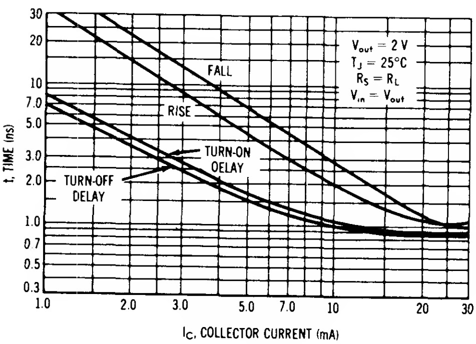
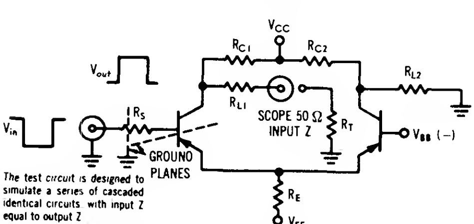


FIGURE 7 — SWITCHING TIMES







The test circuit is designed to simulate a series of cascaded identical circuits with input Z equal to output Z

	$V_{in} = V_{out} = 2$ V $V_{BB} = 1$ V $R_{C1} = R_{C2}$							$V_{in} = V_{out} = 1$ V $V_{BB} = 0.5$ V $R_{C1} = R_{C2}$						
I_C mA	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{EE} volts	V_{CC} volts	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{EE} volts	V_{CC} volts
1	2 k	6 k	3 k	3 k	10 k	10	16	1 k	6 k	1.2 k	1 2 k	24 k	24	32
5	360	3.56 k	400	450	2 k	10	47	175	1 k	200	250	3 k	15	27
10	160	1 k	200	250	3 k	30	26 3	75	300	100	150	3 k	30	17
20	62	300	100	150	1 k	20	16	25	150	25	75	1 k	20	11
30	28	157	66	116	1 k	30	13	8	77	0	50	1 k	30	9

FIGURE 8 — CAPACITANCE

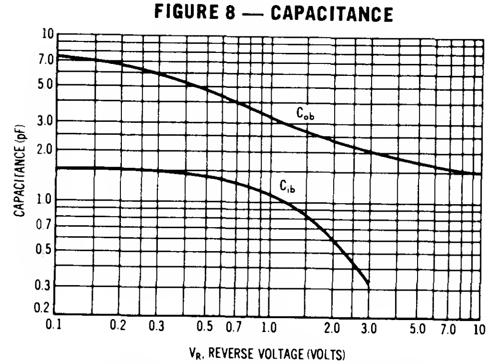
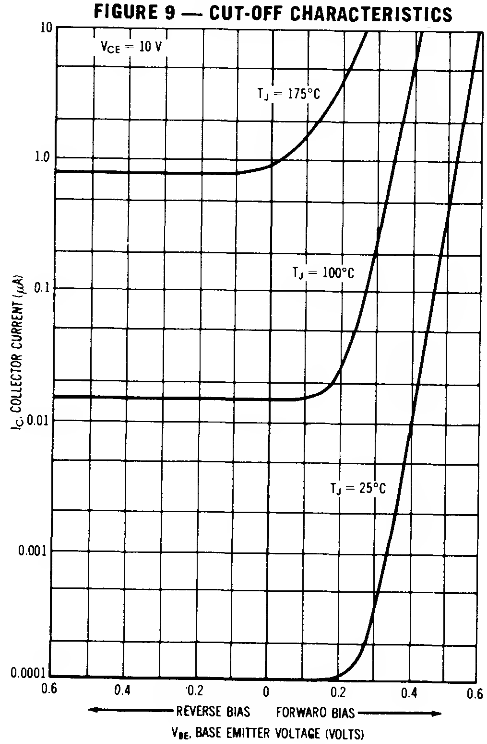


FIGURE 9 — CUT-OFF CHARACTERISTICS



4

2N4404
2N4405

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	8.75 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ µAdc, $I_E = 0$)		$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ µAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$)		I_{CBO}	—	25	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	25	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	2N4404 2N4405	h_{FE}	30 75	— —	—
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	2N4404 2N4405		40 100	— —	
($I_C = 150$ mAdc, $V_{CE} = 5.0$ Vdc)(1)	2N4404 2N4405		40 100	120 300	
($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)(1)	2N4404 2N4405		30 50	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)(1) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)(1)		$V_{CE(sat)}$	— — —	0.15 0.2 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)(1)		$V_{BE(sat)}$	— 0.85	0.8 1.2	Vdc
Base-Emitter On Voltage ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	200	600	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{eb}	—	75	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_s	—	175	ns
Fall Time		t_f	—	35	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON

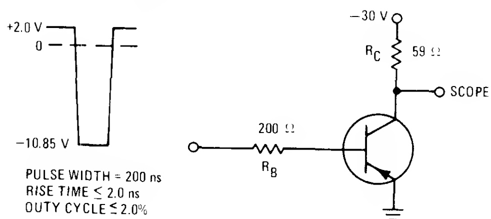
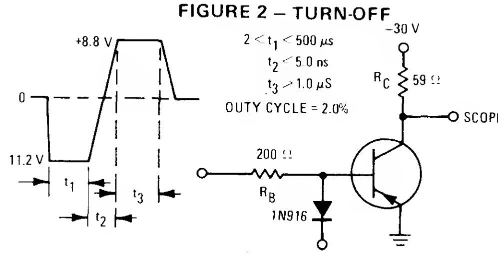


FIGURE 2 — TURN-OFF



To obtain data for curves, voltage levels are approximately as shown, R_B and R_C are varied.

TRANSIENT CHARACTERISTICS

——— 25°C — — — 100°C

FIGURE 3 — CAPACITANCES

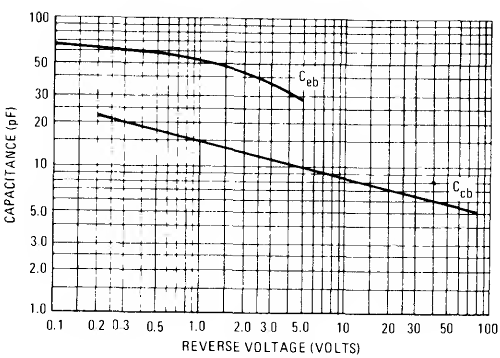


FIGURE 4 — CHARGE DATA

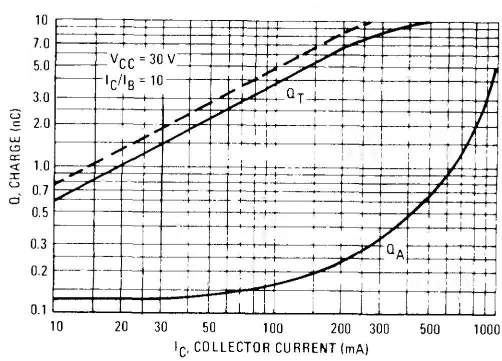


FIGURE 5 — DELAY TIME

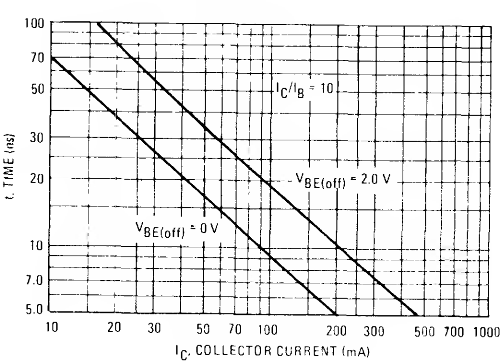


FIGURE 6 — RISE TIME

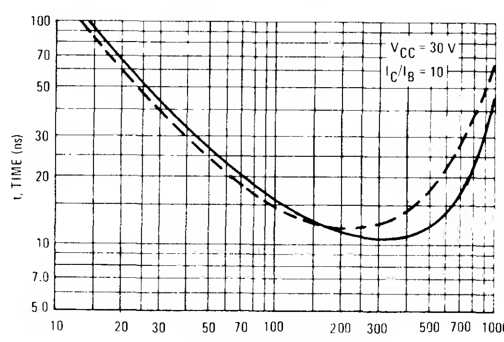


FIGURE 7 – STORAGE TIME

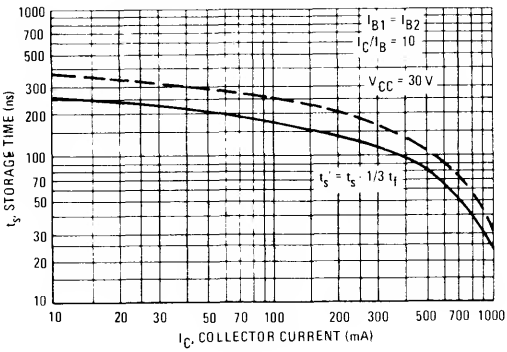
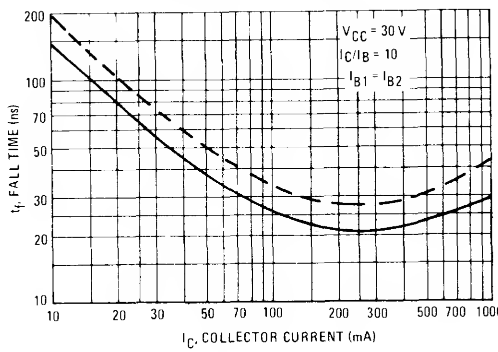


FIGURE 8 – FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 10$ Vdc, $T_A = 25°C$

FIGURE 9 – FREQUENCY EFFECTS

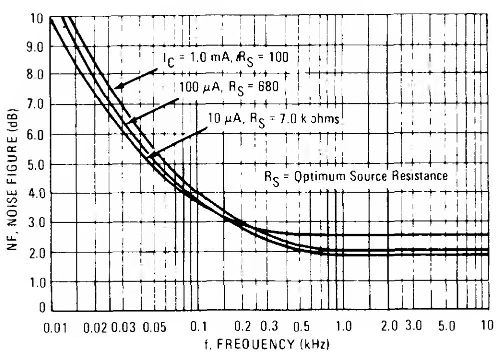
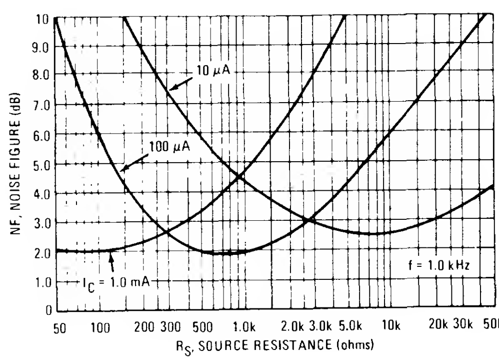


FIGURE 10 – SOURCE RESISTANCE EFFECTS



h PARAMETERS

$V_{CE} = 10$ Vdc, f = 1.0 kHz, $T_A = 25°C$

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number – the same units were used to develop curves on each graph

FIGURE 11 – CURRENT GAIN

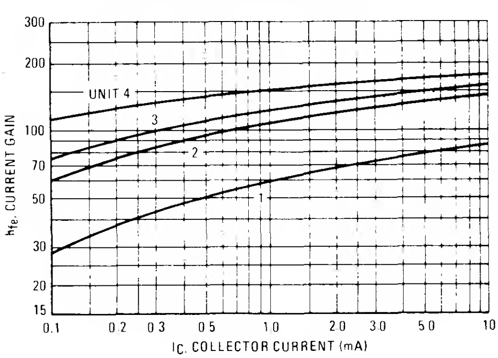


FIGURE 12 – INPUT IMPEDANCE

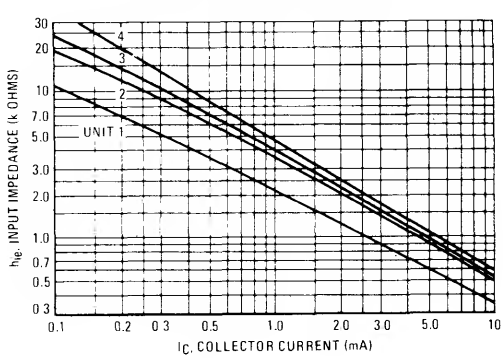


FIGURE 13 – VOLTAGE FEEDBACK RATIO

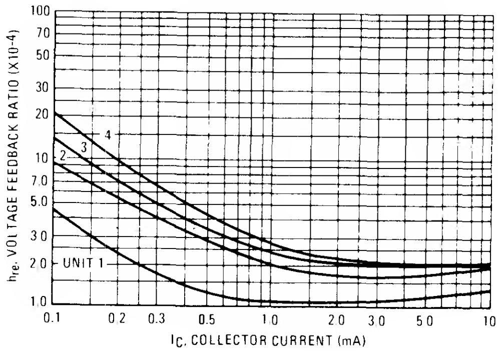
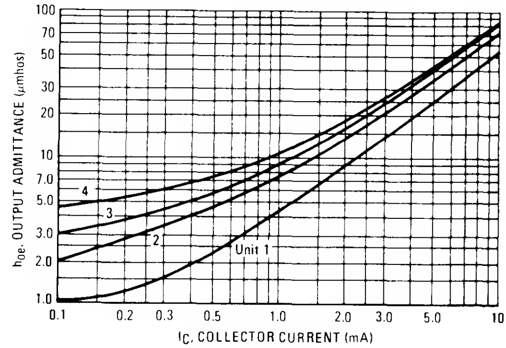


FIGURE 14 – OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

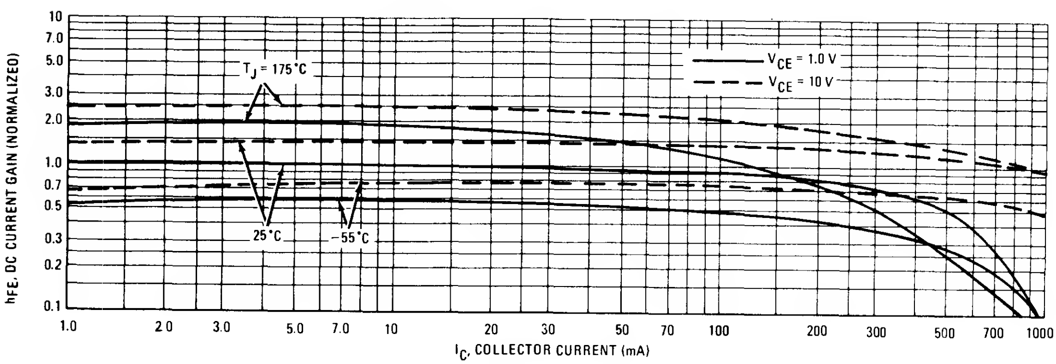


FIGURE 16 – COLLECTOR SATURATION REGION

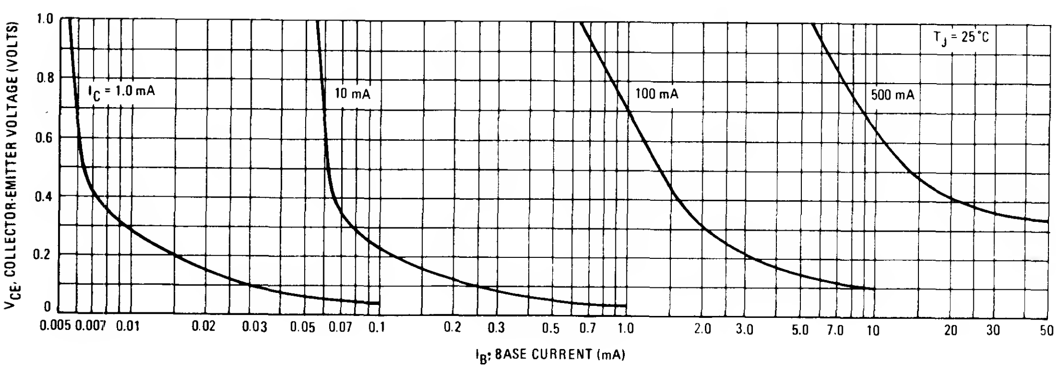


FIGURE 17 – "ON" VOLTAGES

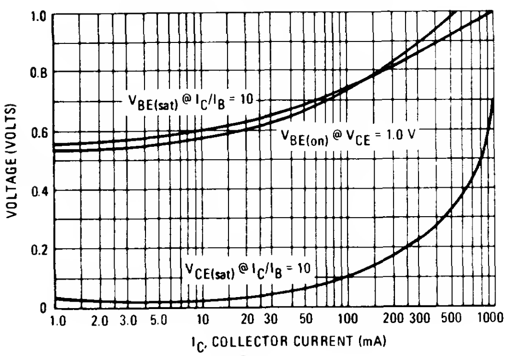
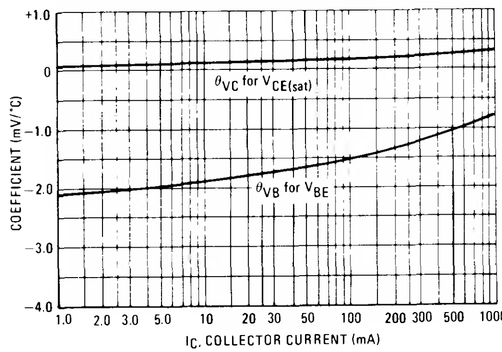
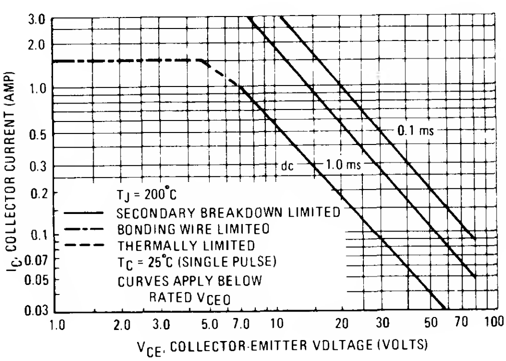


FIGURE 18 – TEMPERATURE COEFFICIENTS



RATINGS AND THERMAL DATA

FIGURE 19 – SAFE OPERATING AREA



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 19 is based upon $T_{J(pk)}$ = 200°C. T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 200°C. $T_{J(pk)}$ may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

4

2N4406
2N4407

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	2.0	Amps
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	8.75 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	80	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ µAdc, $I_E = 0$)		$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ µAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$)		I_{CBO}	—	25	µAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	25	µAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.5$ Adc, $V_{CE} = 5.0$ Vdc)	 2N4406 2N4407 2N4406 2N4407 2N4406 2N4407 2N4406 2N4407 2N4406, 2N4407	h_{FE}	 30 80 30 80 30 80 20 30 10	 — — — — 120 240 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc) ($I_C = 1.5$ Adc, $I_B = 150$ mAdc)		$V_{CE(sat)}$	 — — — —	 0.2 0.4 0.7 1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc) ($I_C = 1.5$ Adc, $I_B = 150$ mAdc)		$V_{BE(sat)}$	 — 0.9 —	 0.9 1.3 1.5	Vdc
Base-Emitter On Voltage ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	150	750	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	15	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{eb}	—	160	pF
SWITCHING CHARACTERISTICS					
Delay Time	($V_{CC} = 30$ Vdc, $V_{BE(off)} = 2.0$ Vdc, $I_C = 1.0$ Adc, $I_{B1} = 100$ mAdc)	t_d	—	15	ns
Rise Time		t_r	—	60	ns
Storage Time	($V_{CC} = 30$ Vdc, $I_C = 1.0$ Adc, $I_{B1} = I_{B2} = 100$ mAdc)	t_s	—	175	ns
Fall Time		t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%. *Indicates Data in addition to JEDEC Requirements.

STATIC CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

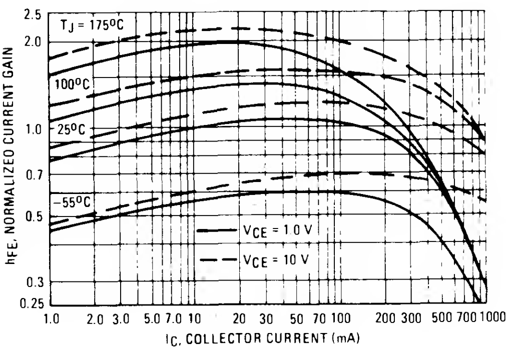


FIGURE 2 — COLLECTOR SATURATION REGION

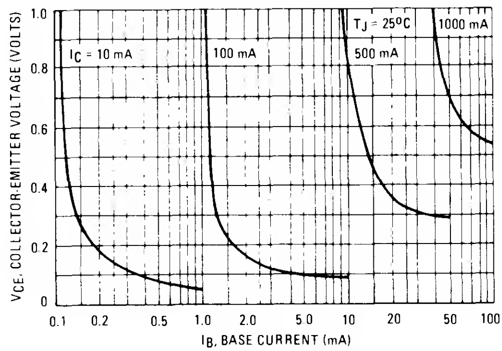


FIGURE 3 — "ON" VOLTAGES

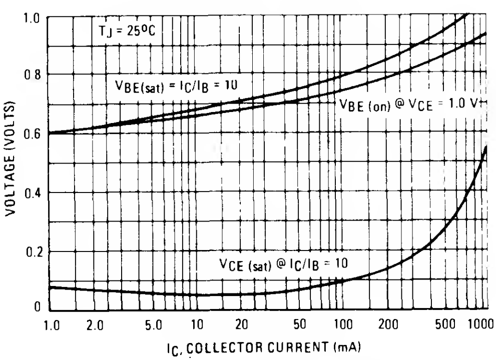


FIGURE 4 — TEMPERATURE COEFFICIENTS

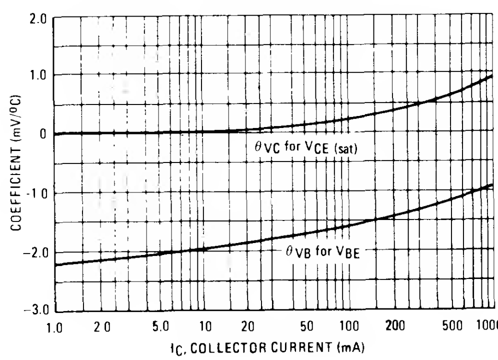
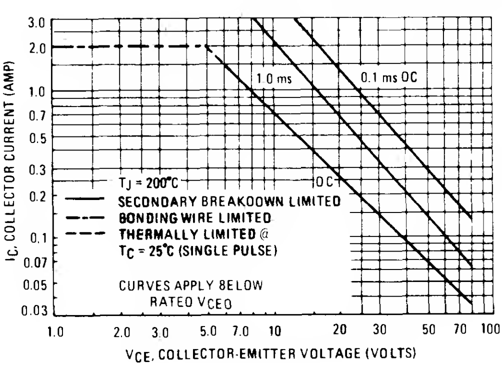


FIGURE 5 — SAFE OPERATING AREA



The safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 5 is based upon $T_{J(pk)} = 200°C$; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TRANSIENT CHARACTERISTICS

——— 25°C — — — 100°C

FIGURE 7 - CAPACITANCES

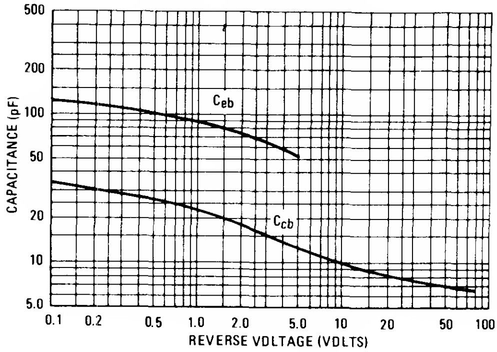


FIGURE 8 - CHARGE DATA

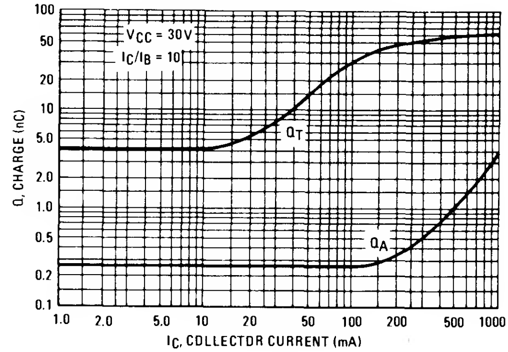


FIGURE 9 - TURN-ON TIME

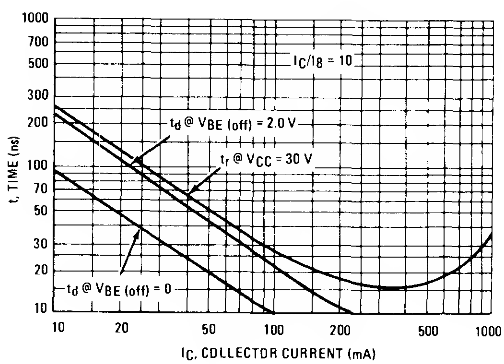
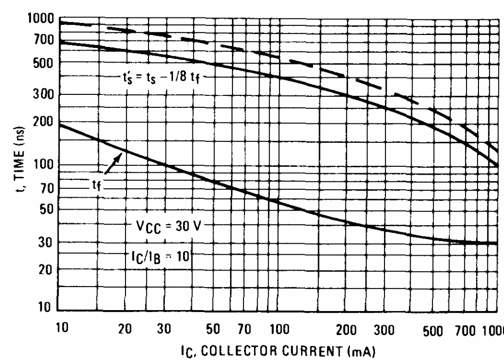


FIGURE 10 - TURN-OFF TIME



SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 11 - TURN-ON TIME

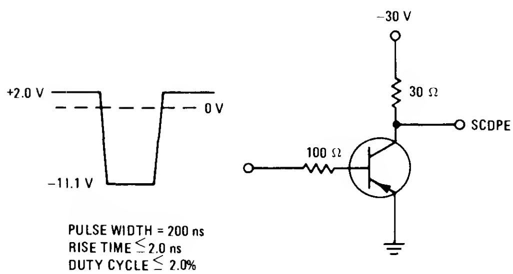
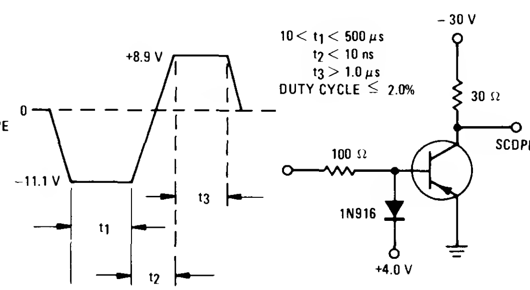


FIGURE 12 - TURN-OFF TIME



2N4453 For Specifications, See 2N869A Data.

2N4890

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

Refer to 2N4033 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 μAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, R_{BE} = 10 ohms)	$V_{(BR)CER}$	50	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	I_{CEX}	—	—	0.25	μAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	I_{BL}	—	—	0.25	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 2.5 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) *(I_C = 500 mA, V_{CE} = 5 Vdc(1)	h_{FE}	 25 50 15	 130 140 —	 — 250 —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.12	1.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	0.82	1.7	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	$V_{BE(on)}$	—	0.74	1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	280	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	9.0	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	60	80	pF
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.8 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	50	ns
Rise Time	t_r	20	20	50	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	110	200	ns
Fall Time	t_f	—	20	70	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

*Indicates Data in Addition to JEDEC Requirements.

2N4924
2N4925

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3498 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	2N4924	2N4925	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Collector-Base Voltage	V_{CBO}	100	150	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	 2N4924 2N4925	$V_{(BR)CEO}$	 100 150	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	 2N4924 2N4925	$V_{(BR)CBO}$	 100 150	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 75$ Vdc, $I_E = 0$)		I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	 25 35 40	 — — 200	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.4	Vdc
Base-Emitter On Voltage ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)		$V_{BE(on)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (2) ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	100	500	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 140 kHz)		C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{EB} = 1.0$ Vdc, $I_C = 0$, f = 140 kHz)		C_{eb}	—	80	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$.

2N4926
2N4927

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N4926	2N4927	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	Vdc
Collector-Base Voltage	V_{CBO}	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	2N4926 2N4927	$V_{(BR)CEO}$	200 250	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_C = 0)	2N4926 2N4927	$V_{(BR)CBO}$	200 250	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 150 Vdc, I_E = 0) (V_{CB} = 150 Vdc, I_E = 0, T_A = 100°C)	2N4926 2N4927	I_{CBO}	— — — —	0.1 10 0.1 10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 20 Vdc)		h_{FE}	10 15 20 20	— — 200 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc)		$V_{CE(sat)}$	— —	1.0 2.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 3.0 mAdc)		$V_{BE(sat)}$	— —	1.2 1.5	Vdc
Base-Emitter On Voltage (I_C = 30 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	—	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	30	300	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)		C_{cb}	—	6.0	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	75	2000	ohm
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	2.0	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	250	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	—	50	μmhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 5.0 MHz)		$Re(h_{ie})$	4.0	200	ohms

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N4928 thru 2N4931

2N4930 and 2N4931 JAN, JTX & JTXV AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N4928	2N4929	2N4930	2N4931	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 3.4	1.0 5.71	1.0 5.71	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 17.2	5.0 28.6	5.0 28.6	5.0 28.6	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200				°C

Refer to 2N3494 for graphs for 2N4928.*

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	2N4928 2N4929 2N4930 2N4931	$V_{(BR)CEO}$	100 150 200 250	— — — —	Vdc
Collector-Base Breakdown Voltage ($I_E = 0$, $I_C = 100$ μAdc)	2N4928 2N4929 2N4930 2N4931	$V_{(BR)CBO}$	100 150 200 250	— — — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 75$ Vdc, $I_E = 0$) ($V_{CB} = 150$ Vdc, $I_E = 0$)	2N4928 2N4929 2N4930, 2N4931	I_{CBO}	— — —	0.5 0.5 1.0	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$) ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	2N4928, 2N4929 2N4930, 2N4931	I_{EBO}	— —	0.5 1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)(1)	All Types 2N4928, 2N4929 2N4930, 2N4931 2N4928, 2N4929 2N4930, 2N4931	h_{FE}	20 25 20 20 20	— 200 200 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	2N4928, 2N4929 2N4930, 2N4931	$V_{CE(sat)}$	— —	0.5 5.0	Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		$V_{BE(on)}$	—	1.0	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4928, 2N4929		100	1,000	
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	2N4930, 2N4931		20	200	
Collector-Base Capacitance		C_{cb}			pF
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	2N4928		—	6.0	
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	2N4929		—	10	
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	2N4930, 2N4931		—	20	
Emitter-Base Capacitance		C_{eb}			pF
(V_{BE} = 2.0 Vdc, I_C = 0, f = 140 kHz)	2N4928		—	40	
(V_{BE} = 1.0 Vdc, I_C = 0, f = 140 kHz)	2N4929		—	80	
(V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	2N4930, 2N4931		—	400	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
Refer to 2N3634 for graphs for 2N4929.
Refer to 2N3743 for graphs for 2N4930 and 2N4931.

2N5022
2N5023

CASE 079-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3467 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	2N5022	2N5023	Unit
Collector-Emitter Voltage	V_{CEO}	50	30	V
Collector-Emitter Voltage	V_{CES}	50	30	V
Collector-Base Voltage	V_{CBO}	50	30	V
Emitter-Base Voltage	V_{EBO}	5		V
Collector Current — Continuous (Pulse Width = 300 μs, DC = 1%)	I_C	1.0*		A
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.72		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Maximum Lead Temperature (Soldering, 60 sec max)	T_L	+300		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	43.8	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

*Indicates Data in Addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc)	2N5022 2N5023	$V_{(BR)CES}$	50 30	— —	V
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc)	2N5022 2N5023	$V_{(BR)CEO(sus)}$*	50 30	— —	V
Collector-Base Breakdown Voltage (I_C = 100 μAdc)	2N5022 2N5023	$V_{(BR)CBO}$	50 30	— —	V
Emitter-Base Breakdown Voltage (I_E = 100 μAdc)	All	$V_{(BR)EBO}$	5.0	—	V
Collector Cutoff Current (V_{CE} = 30 Vdc) (V_{CE} = 20 Vdc) (T_A = 100°Cdc)	 2N5022 2N5023	I_{CES}	 — —	 100 15	 nA μA
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 100 mA, V_{CE} = 1.0 Vdc)	 2N5022 2N5023	h_{FE}	 15 30	 — —	—
(I_C = 500 mA, V_{CE} = 1.0 Vdc)	2N5022 2N5023		25 40	100 100	
(I_C = 1.0 A, V_{CE} = 5.0 Vdc)	2N5022 2N5023		25 40	— —	
(I_C = 500 ma, V_{CE} = 1.0 V, T_A = −55°C)	2N5022 2N5023		10 20	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 100 mAdc, I_B = 10 mAdc)	 2N5022 2N5023	$V_{CE(sat)}$	 — —	 0.20 0.17	 V
(I_C = 500 mAdc, I_B = 50 mAdc)	2N5022 2N5023		— —	0.40 0.35	 V
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N5022 2N5023		— —	0.80 0.70	 V

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			
(I_C = 100 mAdc, I_B = 10 mAdc)			—	1.0	V
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	1.4	V
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	1.75	V
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{BE} = 0.5 V, f = 100 kHz)		C_{cb}	—	25	pF
Emitter-Base Capacitance (V_{BE} = 0.5 V, f = 100 kHz)		C_{eb}	—	100	pF
Small-Signal Current Gain		h_{fe}			—
(I_C = 50 mA, V_{CE} = 10 V, f = 100 MHz)	2N5022		1.7	—	
	2N5023		2.0	—	
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CE} = −30 V, I_C ≈ 500 mA, I_B ≈ 50 mA)		t_{on}	—	40	ns
Turn-Off Time (V_{CE} = 30 V, I_C ≈ 500 mA, I_{B1} = I_{B2} ≈ 50 mA)		t_{off}	—	90	ns

(1) Pulse Width = 300 μs, Duty Cycle = 1.0%.

4

2N5058
2N5059

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3724 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	2N5058	2N5059	Unit
Collector-Emitter Voltage	V_{CEO}	300	250	Vdc
Collector-Base Voltage	V_{CBO}	300	250	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	6.0	Vdc
Collector Current — Continuous	I_C	150		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 6.67		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 33.3		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	30	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	150	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (2) ($I_C = 30$ mAdc, $I_B = 0$)	2N5058 2N5059	$V_{(BR)CEO}$	300 250	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	2N5058 2N5059	$V_{(BR)CBO}$	300 250	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	2N5058 2N5059	$V_{(BR)EBO}$	7.0 6.0	— —	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = +125°C$)		I_{CBO}	— —	0.05 20	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	10	nAdc
ON CHARACTERISTICS (2)					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 25$ Vdc)	2N5058 2N5059	h_{FE}	10 10	— —	—
($I_C = 30$ mAdc, $V_{CE} = 25$ Vdc)	2N5058 2N5059		35 30	150 150	
($I_C = 30$ mAdc, $V_{CE} = 25$ Vdc, $T_A = -55°C$)	2N5058		10	—	
($I_C = 100$ mAdc, $V_{CE} = 25$ Vdc)	2N5058 2N5059		35 30	— —	
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)		$V_{BE(sat)}$	—	0.85	Vdc
Base-Emitter On Voltage ($I_C = 30$ mAdc, $V_{CE} = 25$ Vdc)		$V_{BE(on)}$	—	0.82	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (3) ($I_C = 10$ mAdc, $V_{CE} = 25$ Vdc, f = 20 MHz)		f_T	30	160	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{eb}	—	75	pF

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) f_T is defined as the frequency at which the $|h_{fe}|$ extrapolates to unity.

2N5229
2N5230
2N5231

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

LOW POWER CHOPPER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N5229	2N5230	2N5231	Unit
Emitter-Collector Voltage	V_{ECO}	10	20	30	Vdc
Collector-Base Voltage	V_{CBO}	15	30	50	Vdc
Emitter-Base Voltage	V_{EBO}	15	30	50	Vdc
Collector Current — Continuous	I_C		50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		0.5 2.86		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		2.0 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Emitter-Collector Breakdown Voltage (I_E = 10 μAdc, I_B = 0)	2N5229 2N5230 2N5231	$V_{(BR)ECO}$	10 20 30	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N5229 2N5230 2N5231	$V_{(BR)CBO}$	15 30 50	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	2N5229 2N5230 2N5231	$V_{(BR)EBO}$	15 30 50	— — —	Vdc
Collector Cutoff Current (V_{CB} = 12 Vdc, I_E = 0) (V_{CB} = 25 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0)	2N5229 2N5230 2N5231	I_{CBO}	— — —	1.0 1.0 1.0	nAdc
Emitter Cutoff Current (V_{EB} = 12 Vdc, I_C = 0) (V_{EB} = 25 Vdc, I_C = 0) (V_{EB} = 40 Vdc, I_C = 0)	2N5229 2N5230 2N5231	I_{EBO}	— — —	1.0 1.0 1.0	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 1.0 Vdc) (I_C = 200 μAdc, V_{CE} = 0.5 Vdc) (Inverted Connection)		h_{FE}	50 15	— —	—
Offset Voltage (I_B = 100 μAdc, I_E = 0)	2N5229, 2N5230, 2N5231	$V_{EC(ofs)}$	— —	0.5 0.8	mVdc
(I_B = 1.0 mAdc, I_E = 0)	2N5229, 2N5230, 2N5231		— —	0.8 1.0	
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{cb}	—	5.0	pF
Emitter-Base Capacitance (V_{EB} = 10 Vdc, I_C = 0, f = 140 kHz)		C_{eb}	—	4.0	pF
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 4.0 MHz)		h_{fe}	2.0	—	—

4

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
"ON" Series Resistance (I_B = 1.0 mAdc, I_E = 0, I_e = 100 µA RMS, f = 1.0 kHz)	2N5229	$r_{ec(on)}$	1.0	6.0	Ohms
	2N5230		2.0	8.0	
	2N5231		2.0	10	

TYPICAL CHARACTERISTICS

FIGURE 1 – EMITTER-COLLECTOR VOLTAGE versus BASE CURRENT

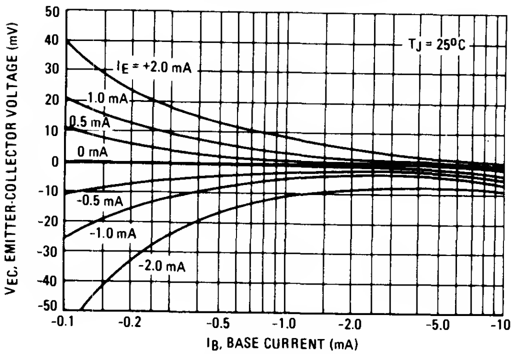


FIGURE 2 – EMITTER-COLLECTOR VOLTAGE versus JUNCTION TEMPERATURE

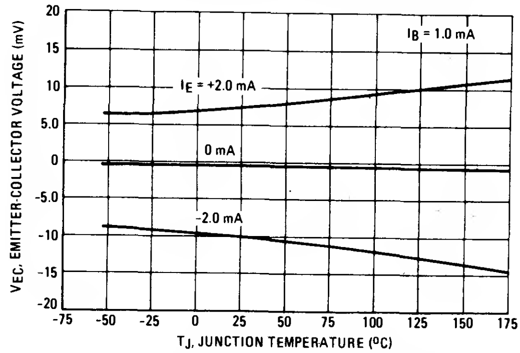


FIGURE 3 – EMITTER-COLLECTOR "ON" RESISTANCE versus BASE CURRENT

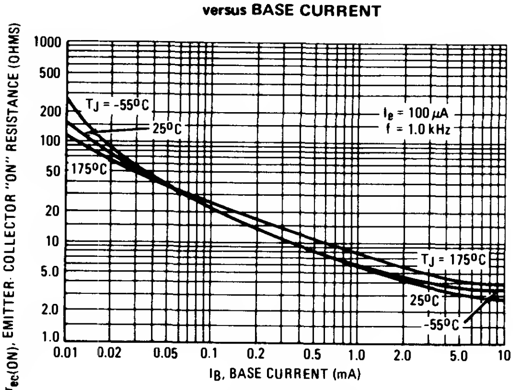


FIGURE 4 – EMITTER-COLLECTOR "ON" RESISTANCE TEMPERATURE COEFFICIENT versus BASE CURRENT

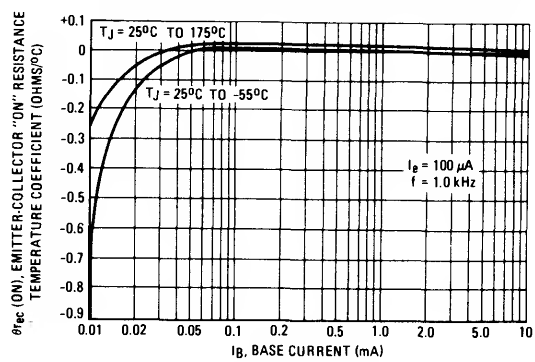


FIGURE 5 – CURRENT GAIN versus COLLECTOR CURRENT

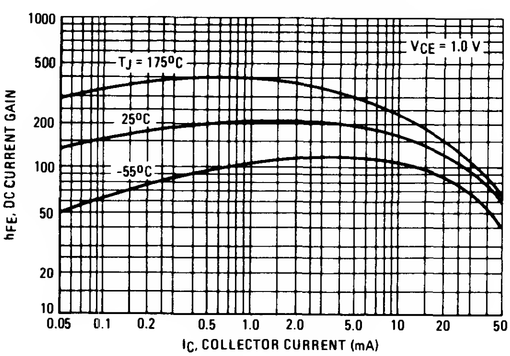


FIGURE 6 – CURRENT GAIN (Inverted Connection) versus EMITTER CURRENT

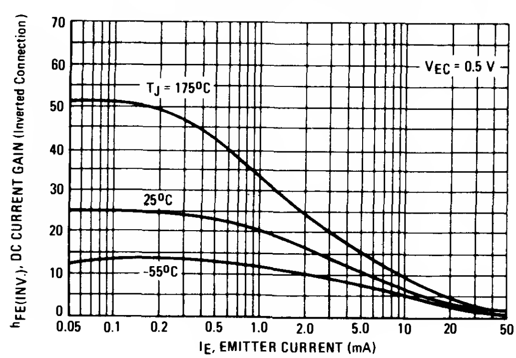


FIGURE 7 – COLLECTOR CUTOFF CURRENT versus JUNCTION TEMPERATURE

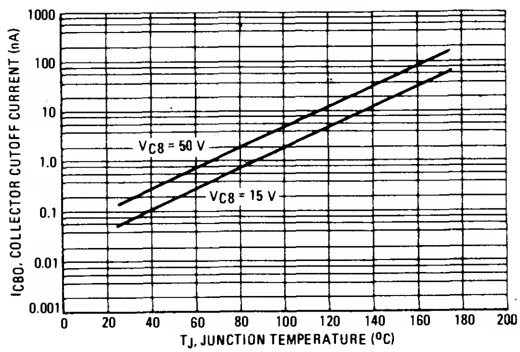


FIGURE 8 – EMITTER CUTOFF CURRENT versus JUNCTION TEMPERATURE

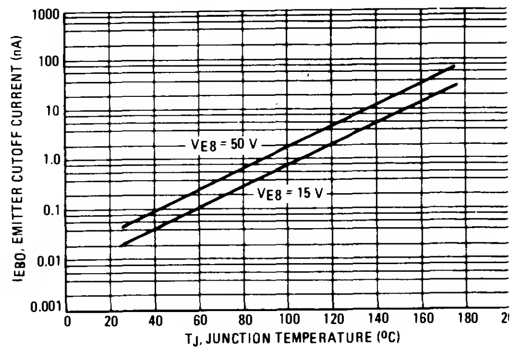


FIGURE 9 – COLLECTOR-EMITTER SATURATION VOLTAGE versus COLLECTOR CURRENT

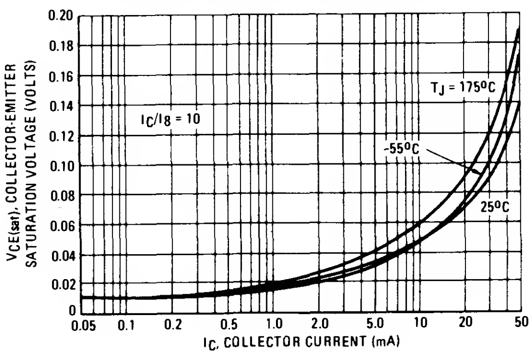
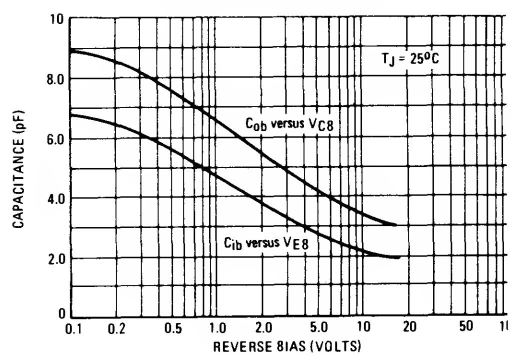


FIGURE 10 – JUNCTION CAPACITANCE versus REVERSE BIAS VOLTAGE



4

4

2N5320
2N5321

CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5320	2N5321	Unit
Collector-Emitter Voltage	V_{CEO}	75	50	Vdc
Collector-Base Voltage	V_{CBO}	100	75	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	5.0	Vdc
Base Current	I_B	1.0		Adc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	10 0.057		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

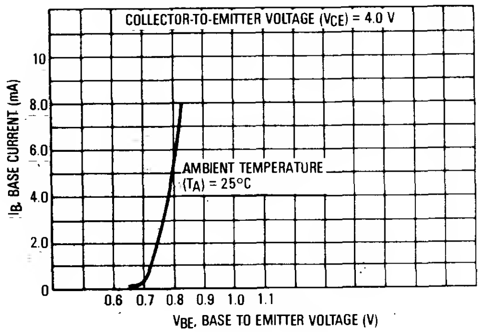
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

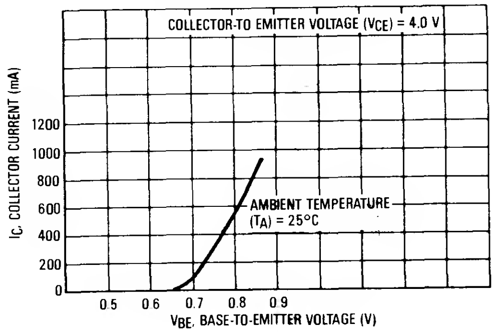
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, $I_B = 0$)	2N5320 2N5321	$V_{(BR)CEO}$	75 50	— —	Vdc
Collector Cutoff Current ($V_{CE} = 100$ Vdc, $V_{BE} = 1.5$ Vdc) ($V_{CE} = 70$ Vdc, $V_{BE} = 1.5$ Vdc, $T_C = 150°C$) ($V_{CE} = 75$ Vdc, $V_{BE} = 1.5$ Vdc) ($V_{CE} = 45$ Vdc, $V_{BE} = 1.5$ Vdc, $T_C = 150°C$)	2N5320 2N5321	I_{CEX}	— — — —	0.1 5.0 0.1 5.0	mAdc
Emitter Cutoff Current ($V_{BE} = 7.0$ Vdc, $I_C = 0$) ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	2N5320 2N5321	I_{EBO}	—	0.1 0.1	mAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 500$ mAdc, $V_{CE} = 4.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 2.0$ Vdc)	2N5320 2N5321 2N5320	h_{FE}	30 40 10	130 250 —	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	2N5320 2N5321	$V_{CE(sat)}$	— —	0.5 0.8	Vdc
Base-Emitter On Voltage ($I_C = 500$ mAdc, $V_{CE} = 4.0$ Vdc)	2N5320 2N5321	$V_{BE(on)}$	—	1.1 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 4.0$ Vdc, f = 10 MHz)		h_{fe}	5	—	—
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30$ Vdc, $I_C = 500$ mAdc, $I_{B1} = 50$ mAdc)		t_{on}	—	80	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 500$ mAdc, $I_{B1} = I_{B2} = 50$ mAdc)		t_{off}	—	800	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.

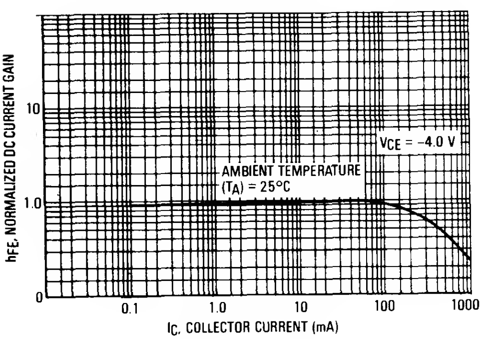
TYPICAL INPUT CHARACTERISTICS



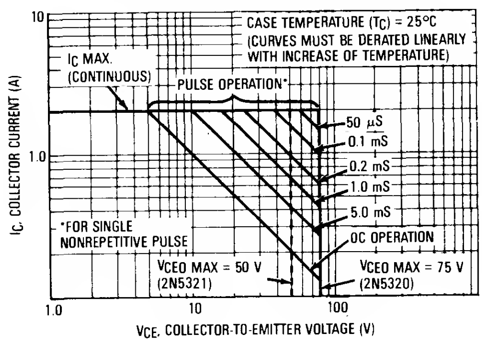
TYPICAL TRANSFER CHARACTERISTICS



CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



MAXIMUM SAFE OPERATING AREAS (SOA)



4

2N5322
2N5323

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N5322	2N5323	Unit
Collector-Emitter Voltage	V_{CEO}	75	50	Vdc
Collector-Base Voltage	V_{CBO}	100	75	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	5.0	Vdc
Base Current	I_B	1.0		Adc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 0.057		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

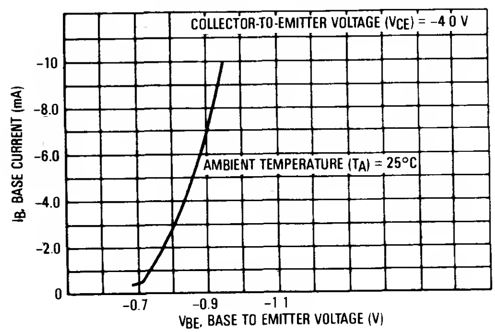
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

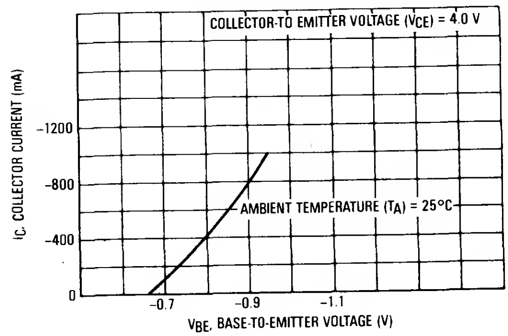
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, I_B = 0)	 2N5322 2N5323	$V_{(BR)CEO}$	 75 50	 — —	Vdc
Collector Cutoff Current (V_{CE} = 100 Vdc, V_{BE} = 1.5 Vdc) (V_{CE} = 70 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C) (V_{CE} = 75 Vdc, V_{BE} = 1.5 Vdc) (V_{CE} = 45 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	 2N5322 2N5323 	I_{CEX}	 — — — —	 0.1 5.0 0.1 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0) (V_{BE} = 5.0 Vdc, I_C = 0)	 2N5322 2N5323	I_{EBO}	 — —	 0.1 0.1	mAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 4.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	 2N5322 2N5323 2N5322	h_{FE}	 30 40 10	 130 250 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	 2N5322 2N5323	$V_{CE(sat)}$	 —	 0.7 1.2	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 4.0 Vdc)	 2N5322 2N5323	$V_{BE(on)}$	 —	 1.1 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 4.0 Vdc, f = 10 MHz)		h_{fe}	5	—	—
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)		t_{on}	—	100	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)		t_{off}	—	1000	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL INPUT CHARACTERISTICS

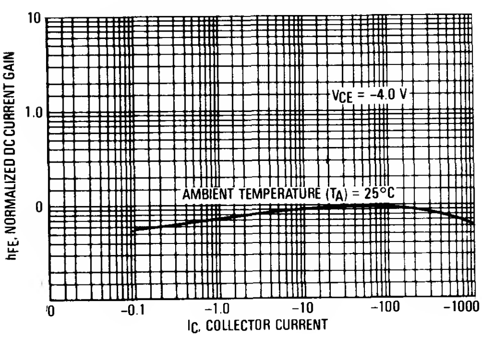


TYPICAL TRANSFER CHARACTERISTICS

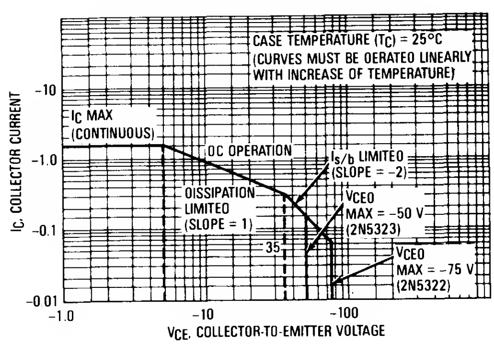


4

CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



MAXIMUM SAFE OPERATING AREAS (SOA)



2N5415, 2N5416

For Specifications, See 2N3439 Data.

2N5581

For Specifications, See 2N2218 Data.

4

2N5679
2N5680

PNP SILICON

2N5681
2N5682

NPN SILICON

CASE 79-02, STYLE 1
TO-5 (TO-205AA)

GENERAL PURPOSE TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	2N5679 2N5681	2N5680 2N5682	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	Vdc
Collector-Base Voltage	V_{CBO}	100	120	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Base Current	I_B	0.5		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 57		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

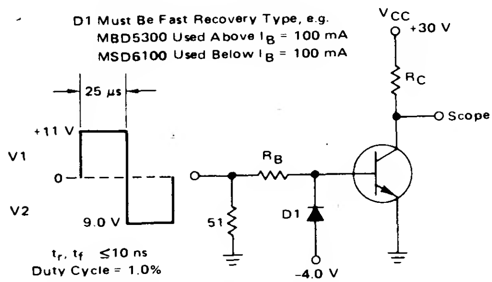
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	 2N5679, 2N5681 2N5680, 2N5682	$V_{CEO(sus)}$	 100 120	 — —	Vdc
Collector Cutoff Current (V_{CE} = 70 Vdc, I_B = 0) (V_{CE} = 80 Vdc, I_B = 0)		I_{CEO}	 — —	 10 10	μAdc
Collector Cutoff Current (V_{CE} = 100 Vdc, V_{EB} = 1.5 Vdc) (V_{CE} = 120 Vdc, V_{EB} = 1.5 Vdc) (V_{CE} = 100 Vdc, V_{EB} = 1.5 Vdc, T_C = 150°C) (V_{CE} = 120 Vdc, V_{EB} = 1.5 Vdc, T_C = 150°C)	 2N5679, 2N5681 2N5680, 2N5682 2N5679, 2N5681 2N5680, 2N5682	I_{CEX}	 — — — —	 1.0 1.0 1.0 1.0	μAdc mAdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 120 Vdc, I_E = 0)	 2N5679, 2N5681 2N5680, 2N5682	I_{CBO}	 — —	 1.0 1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	 40 5.0	 150 —	—
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 25 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 200 mAdc)		$V_{CE(sat)}$	 — — —	 0.6 1.0 2.0	Vdc
Base-Emitter Saturation Voltage (I_C = 250 mAdc, V_{CE} = 2.0 Vdc)		$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	—	—
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	50	pF
Small-Signal Current Gain (I_C = 0.2 Adc, V_{CE} = 1.5 Vdc, f = 1.0 kHz)		h_{fe}	40	—	—

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



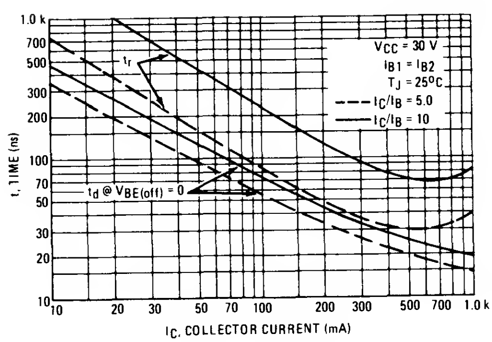
R_B and R_C Varied to Obtain Desired Current Levels

For t_d and t_r, D1 is disconnected and V2 = 0
For PNP test circuit, reverse diode and voltage polarities.

PNP
2N5679, 2N5680

NPN
2N5681, 2N5682

FIGURE 2 – TURN-ON TIME



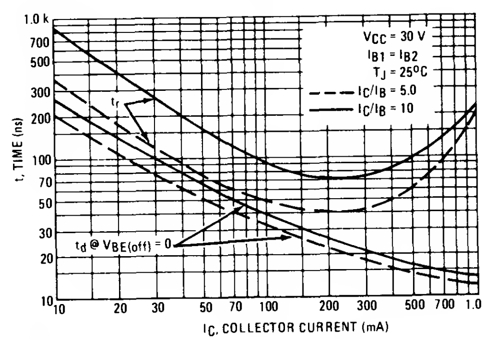
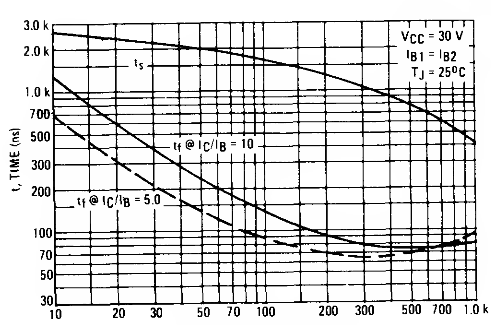


FIGURE 3 – TURN-OFF TIME



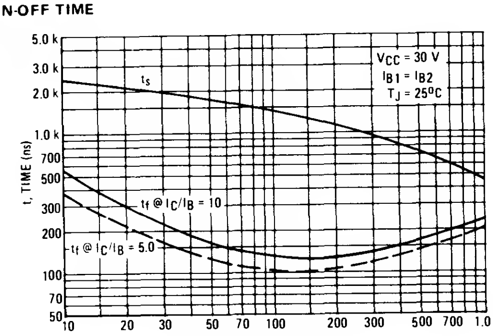


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

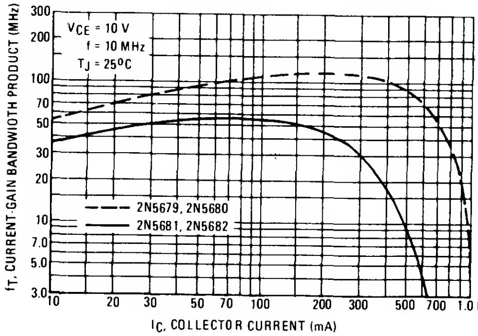


FIGURE 5 – CAPACITANCE

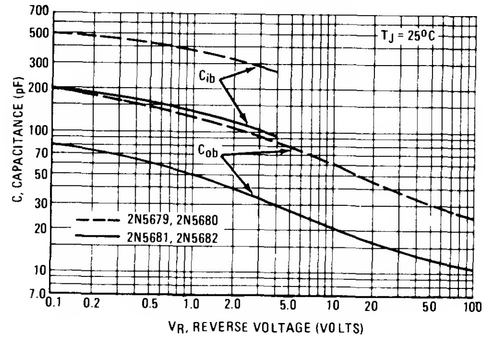


FIGURE 6 – THERMAL RESISTANCE

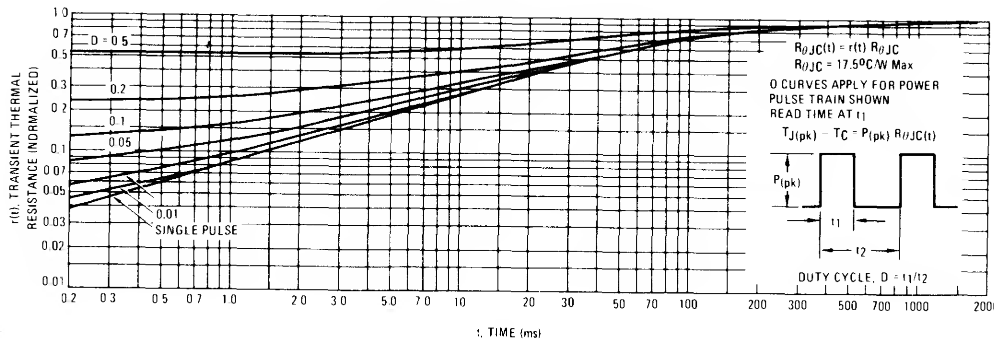


FIGURE 7 – ACTIVE-REGION SAFE OPERATING AREA

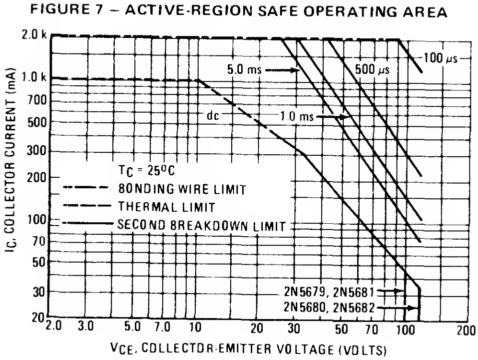
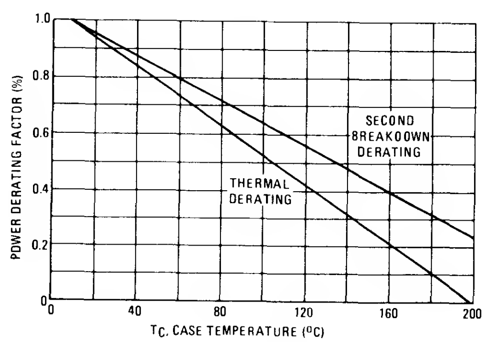


FIGURE 8 – POWER DERATING



There are two limitations on the power handling ability of a transistor average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on T_C = 25°C; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 7 may be found at any case temperature by using the appropriate curve on Figure 8.

PNP
2N5679, 2N5680

NPN
2N5681, 2N5682

FIGURE 9 – DC CURRENT GAIN

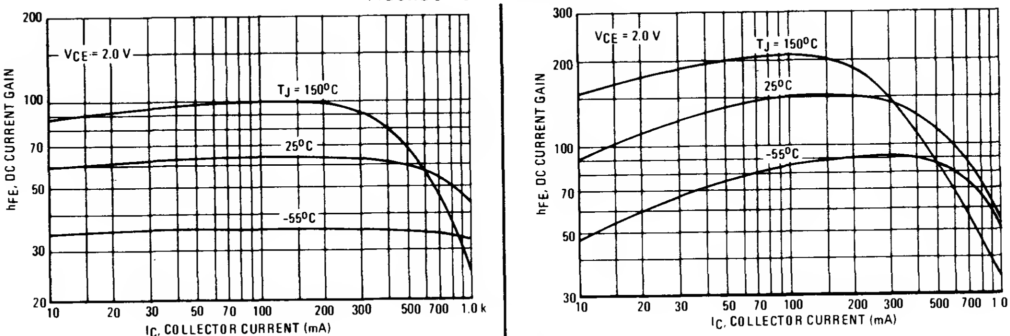


FIGURE 10 – COLLECTOR SATURATION REGION

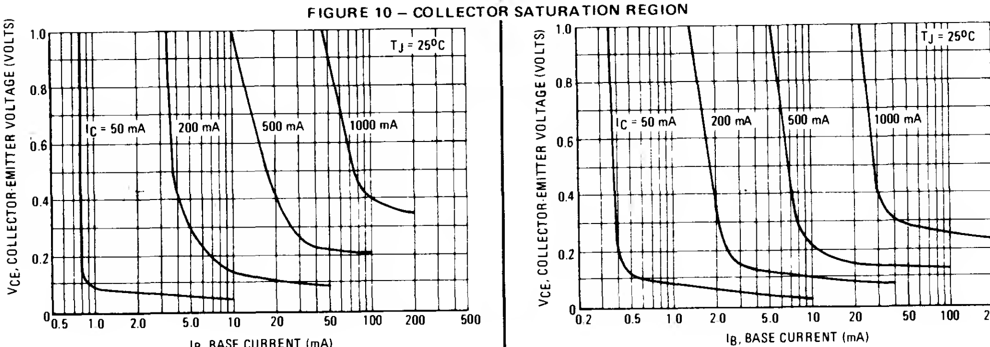
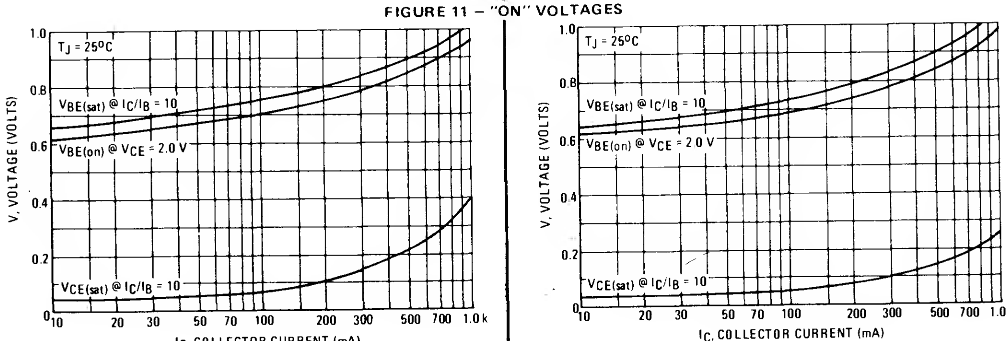


FIGURE 11 – "ON" VOLTAGES

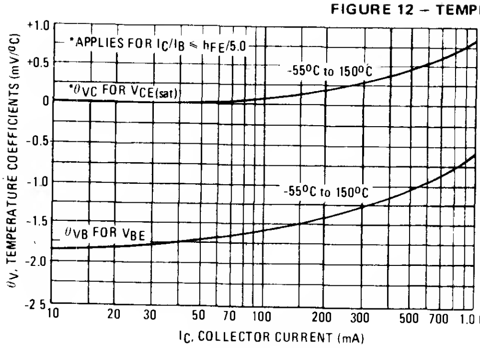


4

PNP
2N5679, 2N5680

NPN
2N5681, 2N5682

FIGURE 12 – TEMPERATURE COEFFICIENTS



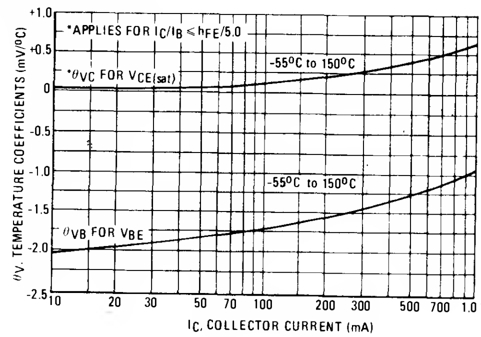
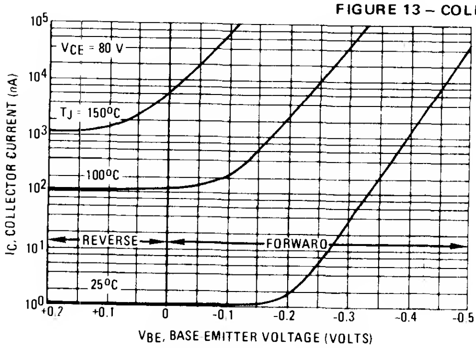


FIGURE 13 – COLLECTOR CUTOFF REGION



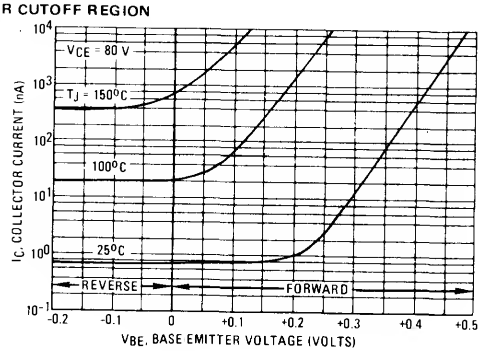
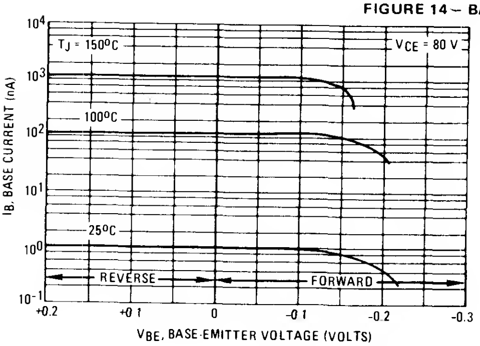
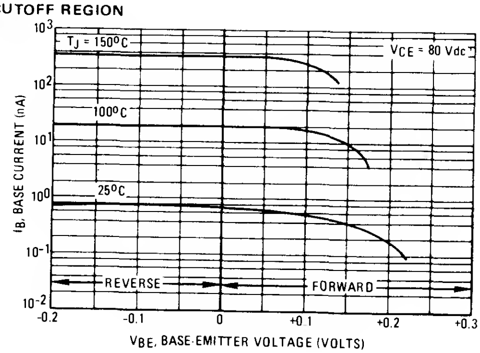


FIGURE 14 – BASE CUTOFF REGION





2N5859

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 6.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

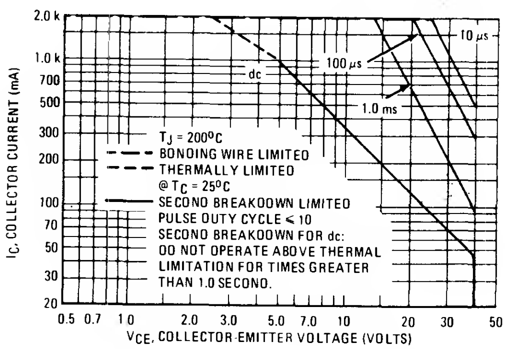
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 50$ Vdc, $V_{BE(off)} = 2.0$ Vdc) ($V_{CE} = 50$ Vdc, $V_{BE(off)} = 2.0$ Vdc, $T_A = 75°C$)	I_{CEX}	— —	0.2 5.0	μAdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 75°C$)	I_{CBO}	— —	0.25 5.0	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)	h_{FE}	30 15 10	120 100 —	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc)	$V_{CE(sat)}$	— —	0.4 0.7	Vdc
Base-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc)	$V_{BE(sat)}$	0.8 0.9	1.0 1.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	250	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{cb}	—	7.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{eb}	—	60	pF
SWITCHING CHARACTERISTICS				
Delay Time ($V_{CC} = 30$ Vdc, $V_{BE(off)} = 2.0$ Vdc, $I_C = 1.0$ Adc, $I_{B1} = 100$ mAdc) (Figures 8 and 10)	t_d	—	6.0	ns
Rise Time ($V_{CC} = 30$ Vdc, $V_{BE(off)} = 2.0$ Vdc, $I_C = 1.0$ Adc, $I_{B1} = 100$ mAdc) (Figures 8 and 10)	t_r	—	30	ns
Storage Time ($V_{CC} = 30$ Vdc, $I_C = 1.0$ Adc, $I_{B1} = I_{B2} = 100$ mAdc) (Figures 9 and 11)	t_s	—	35	ns
Fall Time ($V_{CC} = 30$ Vdc, $I_C = 1.0$ Adc, $I_{B1} = I_{B2} = 100$ mAdc) (Figures 9 and 11)	t_f	—	35	ns

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc) (Figures 8 and 10)	t_{on}	—	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (Figures 9 and 11)	t_{off}	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq$ 200°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

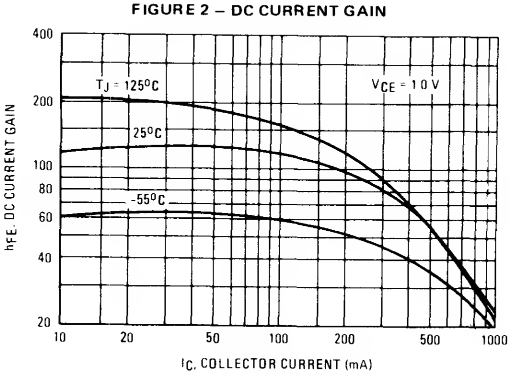


FIGURE 3 – "ON" VOLTAGES

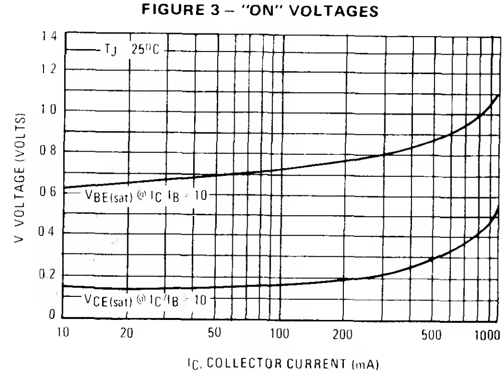


FIGURE 4 – COLLECTOR SATURATION REGION

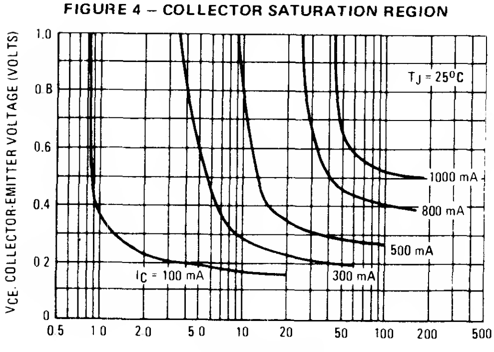
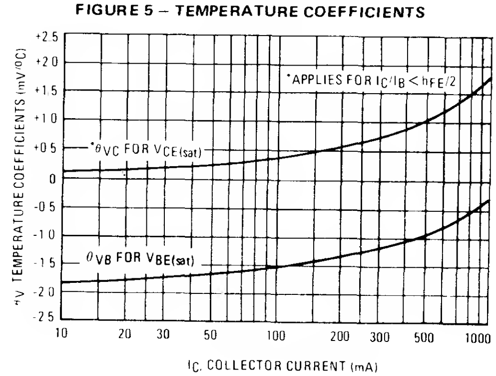


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

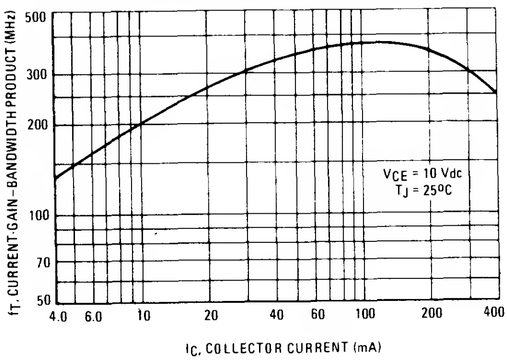


FIGURE 7 – CAPACITANCE

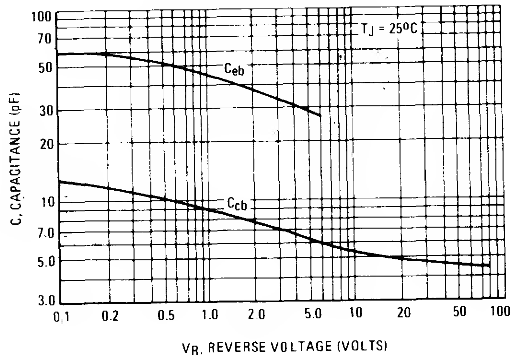


FIGURE 8 – TURN-ON TIME

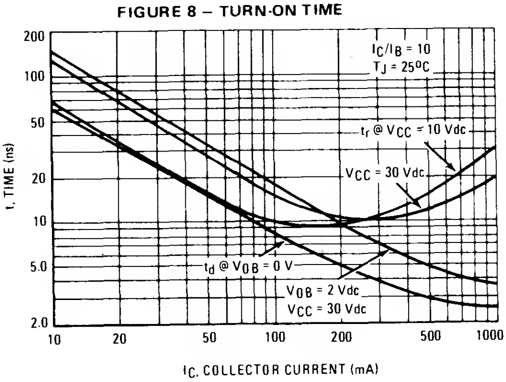


FIGURE 9 – TURN-OFF TIME

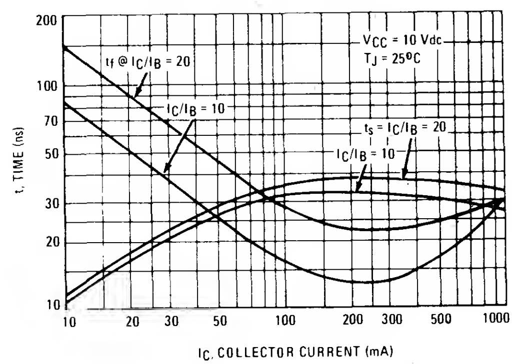


FIGURE 10 – TURN-ON TIME TEST CIRCUIT

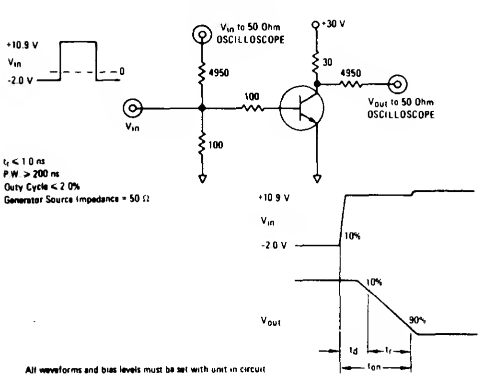
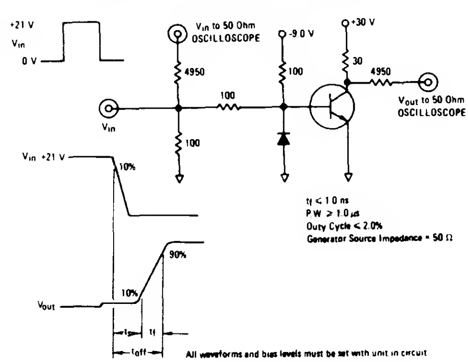


FIGURE 11 – TURN-OFF TIME TEST CIRCUIT



4

2N5861

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 6.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	100	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 2.0 Vdc) (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_A = 75°C)	I_{CEX}	— —	0.3 10	μAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = +75°C)	I_{CBO}	— —	0.3 10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)	h_{FE}	25 10	100 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	7.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	60	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	—	25	ns
Delay Time	t_d	—	8.0	ns
Rise Time	t_r	—	18	ns

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	60	ns
Storage Time		t_s	—	35	ns
Fall Time		t_f	—	35	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 1 — CURRENT-GAIN—BANDWIDTH PRODUCT

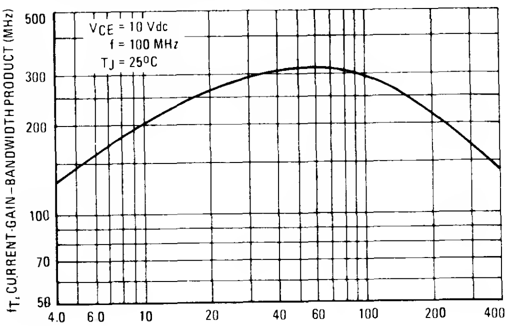


FIGURE 2 — CAPACITANCE

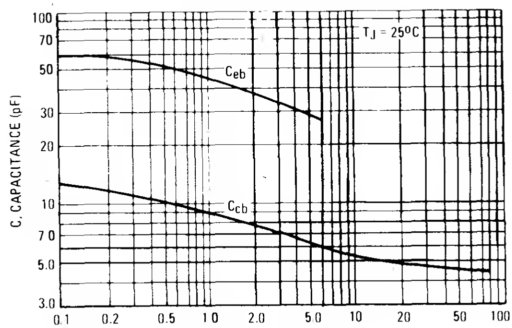


FIGURE 3 — TURN-ON TIME

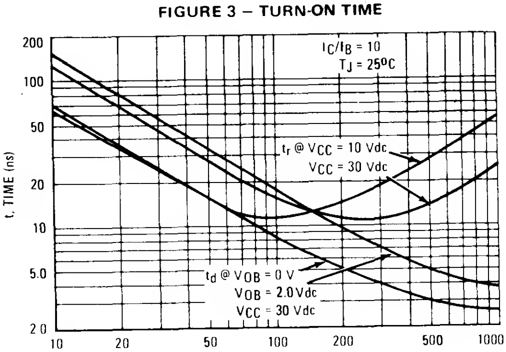


FIGURE 4 — TURN-OFF TIME

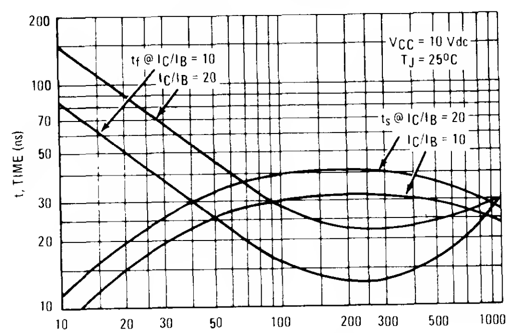
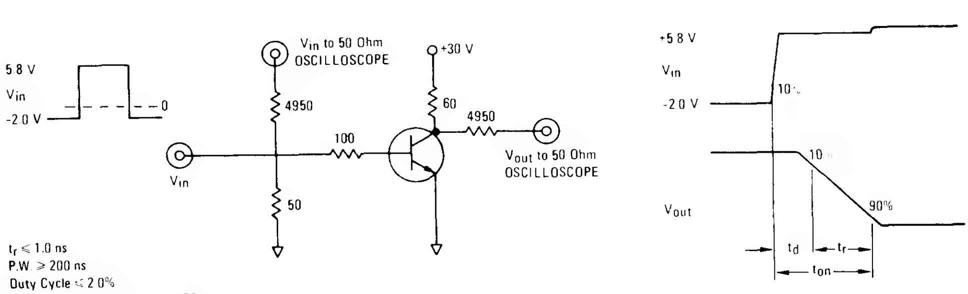


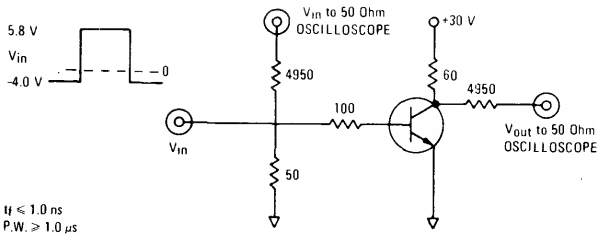
FIGURE 5 — TURN-ON TIME TEST CIRCUIT

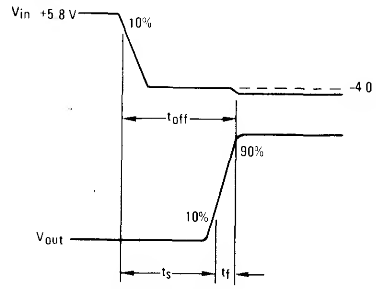


t_r ≤ 1.0 ns
P.W. ≥ 200 ns
Duty Cycle ≤ 2.0%
Generator Source Impedance = 50 Ω
Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope: Tektronix 661 Sampling Scope

V_{in} during t_{on} interval must be +5.8 V.
All waveforms and bias levels must be set with unit in circuit.

FIGURE 6 – TURN-OFF TIME TEST CIRCUIT





$t_f \leq 1.0$ ns
P.W. $\geq 1.0\ \mu s$
Duty Cycle $\leq 2.0\%$
Generator Source Impedance = 50 Ω
Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope: Tektronix 661 Sampling Scope

V_{in} during t_{off} interval must be -4.0 V.
All waveforms and bias levels must be set with unit in circuit.

FIGURE 7 – DC CURRENT GAIN

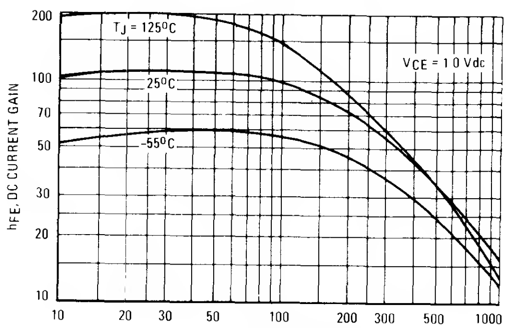


FIGURE 8 – "ON" VOLTAGES

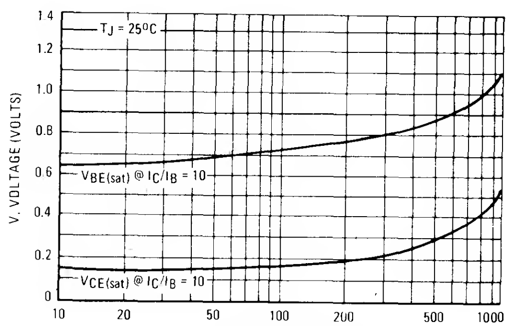


FIGURE 9 – ACTIVE-REGION SAFE OPERATING AREA

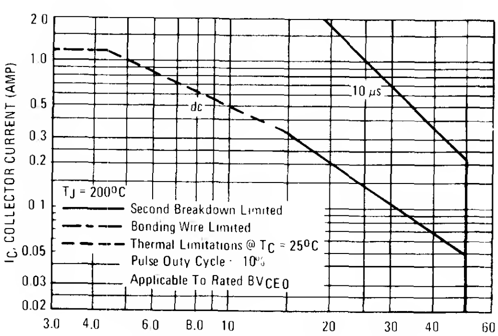
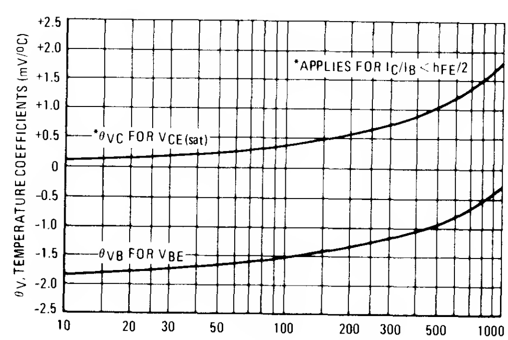


FIGURE 10 — TEMPERATURE COEFFICIENTS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 9 is based on $T_{J(pk)} = 200^{\circ}C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200^{\circ}C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

4

2N6430
2N6431

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N6430	2N6431	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	Vdc
Collector-Base Voltage	V_{CBO}	200	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	50		mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 2.86		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	2N6430 2N6431	$V_{(BR)CEO}$	200 300	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	2N6430 2N6431	$V_{(BR)CBO}$	200 300	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 160$ Vdc) ($V_{CB} = 200$ Vdc)	2N6430 2N6431	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25 40 50	— — 200	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	500	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

2N6432
2N6433

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3743 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N6432	2N6433	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	Vdc
Collector-Base Voltage	V_{CBO}	200	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 2.86		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	2N6432 2N6433	$V_{(BR)CEO}$	200 300	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	2N6432 2N6433	$V_{(BR)CBO}$	200 300	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 160$ Vdc) ($V_{CB} = 200$ Vdc)	2N6432 2N6433	I_{CBO}	— —	0.25 0.25	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25 40 30	— — 150	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)		f_T	50	500	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	6.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BC107
BC108
BC109

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BC 107	BC 108	BC 109	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	30	Vdc
Emitter-Base Voltage	V_{EBO}	6	5	5	Vdc
Collector Current – Continuous	I_C	0.2			Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 2.28			Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1 6.67			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Base Leakage Current (I_E = 0, V_{CB} = 45 V) (I_E = 0, V_{CB} = 45 V, T_{Amb} = 125°C) (I_E = 0, V_{CB} = 25 V) (I_E = 0, V_{CB} = 25 V, T_{Amb} = 125°C)	 BC107 BC107 BC108/109 BC108/109	I_{CBO}			 15 4 15 4	 nA µA nA µA
Emitter Base Breakdown Voltage (I_E = 10 µA, I_C = 0)	 BC107 BC108/109	$V_{(BR)EBO}$	 6 5			V
Collector Emitter Breakdown Voltage (I_C = 2 mA, I_E = 0)	 BC107 BC108/109	$V_{(BR)CEO}$	 45 25			V
ON CHARACTERISTICS						
DC Current gain (V_{CE} = 5 V, I_C = 2 mA)	 BC107 BC108 BC109 A group B group C group	h_{FE}	 110 110 200 110 200 420		 450 800 800 220 450 800	
(V_{CE} = 5 V, I_C = 10 µA)	B group C group		40 100			
Base Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5 mA)		$V_{BE(sat)}$		 0.7 1.0	 0.83 1.05	V
Collector Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5 mA)		$V_{CE(sat)}$			 0.25 0.60	V
Base Emitter on Voltage (I_C = 2 mA, V_{CE} = 5 V) (I_C = 10 mA, V_{CE} = 5 V)		$V_{BE(on)}$	 0.55		 0.70 0.77	V
Collector Knee Voltage (I_C = 10 mA, I_B = the value for which I_C = 11 mA at V_{CE} = 1 V)		$V_{CE(K)}$		0.4	0.6	V
DYNAMIC CHARACTERISTICS						
Transition Frequency (I_C = 10 mA, f = 100 MHz, V_{CE} = 5 V)		f_T	150	300		MHz
Noise Figure (V_{CE} = 5 V, I_C = 0.2 mA, R_g = 2 KΩ) F = 30 Hz to 15 kHz F = 1 kHz, ΔF = 200 Hz	 BC109 BC109 BC107/108	NF			 4 4 10	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{CB} = 10 V, f = 1 MHz)		C_{obo}			4.5	pF
h_{21e} Parameters (V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz)	BC107/108	h_{21e}	125		500	
	BC109		240		900	
	A group		125		260	
	B group		240		500	
	C group		450		900	
h_{11e} Parameters (V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz)	A group	h_{11e}	1.6		4.5	KΩ
	B group		3.2		8.5	
	C group		6.0		15	
h_{22e} Parameters (V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz)	A group	h_{22e}			30	µhos
	B group				60	
	C group				110	

FIGURE 1 — EMITTER-BASE CAPACITANCE COLLECTOR-BASE CAPACITANCE

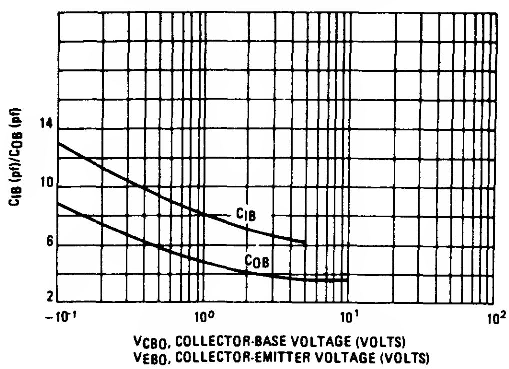


FIGURE 2 — CURRENT GAIN — BANDWIDTH PRODUCT

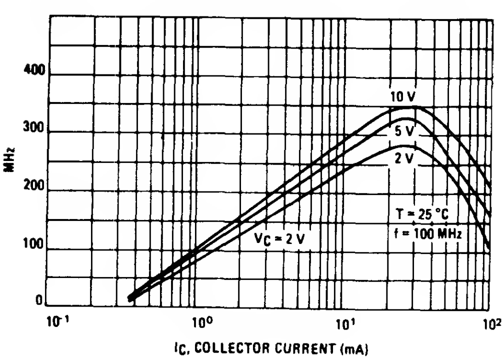
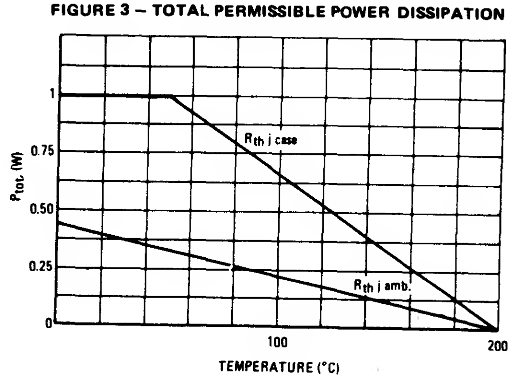


FIGURE 3 — TOTAL PERMISSIBLE POWER DISSIPATION



BC140
BC141

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	BC 140	BC 141	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	7		Vdc
Collector Current – Continuous	I_C	1		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.B 4.6		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.7 20		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current (I_E = 0, V_{CE} = 60 V)	 T_{Amb} = 150°C	I_{CES}		100 100	nA µA
Collector-Emitter Breakdown Voltage (I_{CES} = 100 µA, I_E = 0)	BC140 BC141	$V_{(BR)CES}$	80 100		V
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mA, I_B = 0)	BC140 BC141	$V_{(BR)CEO}$	40 60		V
Emitter-Base Breakdown Voltage (I_E = 100 µA, I_C = 0)		$V_{(BR)EBO}$	7		V
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 100 mA, V_{CE} = 1 V)	for BC140, 141 for BC140, 141 Group 6 for BC140, 141 Group 10 for BC140, 141 Group 16	h_{FE}	40 40 63 100	400 100 160 250	
Collector-Emitter Saturation Voltage(1) (I_C = 1 A, I_B = 0.1 A)		$V_{CE(sat)}$		1	V
Base-Emitter Voltage(1) (I_C = 1 A, V_{CE} = 1 V)		$V_{BE(on)}$		2	V
SMALL SIGNAL CHARACTERISTICS					
Gain Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 20 MHz)		f_T	50		MHz
Input Capacitance (V_{EB} = 0,5 V, I_C = 0, f = 1 MHz		C_{ib}		80	pF
Capacitance (I_E = 0, V_{CB} = 10 V, f = 1 MHz)		C_{ob}		25	pF
Turn On Time (I_C = 150 mA, I_{B1} = 7.5 mA)		t_{on}		250	ns
Turn Off Time (I_C = 150 mA, I_{B1} = I_{B2} = 7.5 mA)		t_{off}		B50	ns

(1) Pulsed: Pulse Duration = 300 µs, Duty Cycle = 1%.

BC160
BC161

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4033 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	BC 160	BC 161	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	40	60	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current – Continuous	I_C	1		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.7 20		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current I_E = 0, V_{CES} = −40 V for BC160 V_{CES} = −60 V for BC161 V_{CES} = −40 V for BC160 T_{Amb} = 150°C V_{CES} = −60 V for BC161 T_{Amb} = 150°C	I_{CES}		−100 −100 −100 −100	nA μA
Collector Emitter Breakdown Voltage I_C = −100 μA, I_E = 0 for BC160 for BC161	$V_{(BR)CES}$	−40 −60		V
Collector-Emitter Breakdown Voltage(1) I_C = −10 mA, I_B = 0 for BC160 for BC161	$V_{(BR)CEO}$	−40 −60		V
Emitter-Base Breakdown Voltage I_E = −100 μA, I_C = 0	$V_{(BR)EBO}$	−5		V
ON CHARACTERISTICS				
DC Current Gain(1) I_C = −100 mA, V_{CE} = −1 V for BC160, BC161 for BC160, BC161 Group 6 for BC160, BC161 Group 10 for BC160, BC161 Group 16	h_{FE}	40 40 63 100	400 100 160 250	
Collector-Emitter Saturation Voltage(1) (I_C = −1 A, I_B = −0.1 A)	$V_{CE(sat)}$		−1	V
Base-Emitter Voltage(1) (I_C = −1 A, V_{CE} = −1 V)	$V_{BE(on)}$		−1.7	V
SMALL SIGNAL CHARACTERISTICS				
Gain Bandwidth Product (I_C = −50 mA, V_{CE} = −10 V, f = 20 MHz	f_T	50		MHz
Input Capacitance (V_{EB} = −10 V, f = 1 MHz)	C_{ib}		180	pF
Output Capacitance (V_{CB} = −10 V, I_E = 0, f = 1 MHz)	C_{obo}		30	pF
Turn On Time (I_C = −100 mA, I_{B1} = −5 μA)	T_{on}		500	ns
Turn Off Time (I_C = −100 mA, I_{B1} = I_{B2} = −5 μA)	T_{off}		650	ns

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

BC177
BC178
BC179

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BC 177	BC 178	BC 179	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	20	Vdc
Collector-Emitter Voltage	V_{CES}	50	30	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	25	Vdc
Emitter-Base Voltage	V_{EBO}	5			Vdc
Collector Current – Continuous	I_C	0.2			Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 2.28			Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1 6.67			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Emitter Leakage Current (V_{CE} = 20 V, I_E = 0) (V_{CE} = 20 V, I_E = 0, T_{Amb} = 125°C)		I_{CES}			100 4	nA μA
Collector Base Breakdown Voltage (I_C = 10 μA)	BC177 BC178 BC179	$V_{(BR)CBO}$	50 30 25			V
Collector Emitter Breakdown Voltage (I_C = 2 mA, I_E = 0)	BC177 BC178 BC179	$V_{(BR)CEO}$	45 25 20			V
Emitter Base Breakdown Voltage (I_E = 10 μA, I_C = 0)		$V_{(BR)EBO}$	5			V
ON CHARACTERISTICS						
DC Current Gain (I_C = 2 mA, V_{CE} = 5 V)	BC177 BC178 BC179 V1 Group A Group B Group C Group	h_{FE}	120 120 180 70 120 180 380		460 800 800 140 220 460 800	
Collector Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5 mA)		$V_{CE(sat)}$			0.2 0.6	V
Base Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 100 mA, I_B = 5 mA)		$V_{BE(sat)}$		0.7 0.9	0.8	V
Base Emitter on Voltage (I_C = 2 mA, V_{CE} = 5 V)		$V_{BE(on)}$	0.6		0.75	V
Collector Knee Voltage (I_C = 10 mA, I_B = the value for which I_C = 11 mA, at V_{CE} = 1V)		$V_{CE(K)}$		0.4	0.6	V
DYNAMIC CHARACTERISTICS						
Transition Frequency (V_{CE} = 5 V, I_C = 10 mA, f = 50 MHz)		f_T	200	300		MHz
Noise Figure (V_{CE} = 5 V, I_C = 0.2 mA, R_g = 2 KΩ) F = 30 Hz to 15 kHz F = 1 kHz, F = 200 Hz	 BC179 BC179 BC177/178	NF			 4 4 10	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{CB} = 10 V, f = 1 MHz)		C_{obo}		3.5	4	pF
h_{21e} Parameters (V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz)	BC177	h_{21e}	125		500	
	BC178		125		900	
	BC179		240		900	
	V1 Group		75		150	
	A Group		125		260	
	B Group		240		500	
	C Group		450		900	
h_{11e} Parameters (V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz)	V1 Group	h_{11e}	1.0		2.2	KΩ
	A Group		1.6		4.5	
	B Group		3.2		8.5	
	C Group		6.0		15.0	
h_{22e} Parameters (V_{GE} = 5 V, I_C = 2 mA, f = 1 kHz)	V1 Group	h_{22e}			25	μmhos
	A Group				30	
	B Group				60	
	C Group				110	

4

BC393

PNP

BC394

NPN

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

HIGH VOLTAGE TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	BC 393	BC 394	Unit
Collector-Emitter Voltage	V_{CEO}	180	180	Vdc
Collector-Base Voltage	V_{CBO}	180	180	Vdc
Emitter-Base Voltage	V_{EBO}	6	6	Vdc
Collector Current — Continuous	I_C	0.5		Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 2.66		Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.5 10.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	$V_{(BR)CEO}$	180			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	180			Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6			Vdc
Collector Cutoff Current (V_{CB} = 100 V, I_E = 0)	I_{CBO}			50	nA
Collector-Emitter Cutoff (V_{CE} = 100 V, I_B = 0) (T_{Amb} = 150°C)	I_{CEO}			50	μA
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mA, V_{CE} = 10 V)	h_{FE}	50	100		
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$		0.15	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$		0.7	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	110	200	MHz
Output Capacitance (I_E = 0, V_{CB} = 20 Vdc, f = 1 MHz)	C_{obo}	—	3.5	7	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1 MHz)	C_{ib}	—	75	—	pF
Turn-On Time (I_{B1} = 10 mA, I_C = 50 mAdc, V_{CC} = 100 Vdc))	t_{on}	—	100	—	ns
Turn-Off Time (I_{B2} = 10 mAdc, I_C = 50 mAdc, V_{CC} = 100 Vdc))	t_{off}	—	400	—	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

BCY58
BCY59

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BCY 58	BCY 59	Unit
Collector-Emitter Voltage	V_{CEO}	32	45	Vdc
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CES}	32	45	Vdc
Emitter-Base Voltage	V_{EBO}	7		Vdc
Collector Current – Continuous	I_C	0.2		Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 2.2B		Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1 6.67		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	150	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	450	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_C = 0)	BCY5B BCY59	$V_{(BR)CEO}$	32 45			Vdc
Emitter-Base Breakdown Voltage (I_E = 1µAdc, I_C = 0)	all	$V_{(BR)EBO}$	7			Vdc
Collector Cutoff Current (V_{CE} = 32 V) (V_{CE} = 45 V)	BCY5B BCY59	I_{CES}		0.2 0.2	10 10	nAdc
(V_{CE} = 32 V, T_A = 100°C, V_{BE} = 0.2 V) (V_{CE} = 45 V, T_A = 100°C, V_{BE} = 0.2 V)	BCY5B BCY59	I_{CEX}			20 20	µAdc
(V_{CE} = 32 V, T_A = 150°) (V_{CE} = 45 V, T_A = 150°)	BCY5B BCY59	I_{CES}		0.2 0.5	10 10	µAdc
Emitter Base Cutoff Current (V_{EB} = 5 V)	all	I_{EBO}			10	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 µAdc, V_{CE} = 5 Vdc)	BCY59-VII, BCY58-VII BCY59-VIII, BCY58-VIII BCY59-IX, BCY58-IX BCY59-X, BCY58-X	h_{FE}	20 40 100 120	145 220 300 170		
(I_C = 2 mAdc, V_{CE} = 5 Vdc)	BCY59-VII, BCY58-VII BCY59-VIII, BCY5B-VIII BCY59-IX, BCY5B-IX BCY59-X, BCY5B-X		1B0 250 3B0 80	250 350 500 190	220 310 460 630	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	BCY59-VII, BCY58-VII BCY59-VIII, BCY5B-VIII BCY59-IX, BCY58-IX BCY59-X, BCY58-X		120 160 240 40	260 3B0 550	400 630 1000	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	BCY59-VII, BCY58-VII BCY59-VIII, BCY5B-VIII BCY59-IX, BCY58-IX BCY59-X, BCY5B-X		45 60 60			
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 2.5 mAdc) (I_C = 10 mAdc, I_B = 0.25 mA)	all	$V_{CE(sat)}$	0.15 0.05	0.30 0.12	0.70 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.25 mA) (I_C = 100 mA, I_B = 2.5 mA)	all	$V_{BE(sat)}$	0.6 0.75	0.70 0.90	0.B5 1.2	Vdc
Base-Emitter on Voltage (I_C = 2 mAdc, V_{CE} = 5 Vdc)	all	$V_{BE(on)}$	0.55	0.62	0.70	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS SMALL SIGNAL CHARACTERISTICS						
Current Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 V, f = 100 MHz)	all	f_T	125	200		MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1 MHz)	all	C_{ob}		3.5	6	pF
Input Capacitance (V_{BE} = 0.5 V, I_C = 0, f = 1 MHz)	all	C_{ib}		8	15	pF
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	BCY58-VII, BCY59-VII	h_{fe} (h_{21e})	125	200	250	
	BCY58-VIII, BCY59-VIII		175	260	350	
	BCY58-IX, BCY59-IX		250	330	500	
	BCY58-X, BCY59-X		350	520	700	
Output Admittance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	BCY58-VII, BCY59-VII	h_{oe} (h_{22e})			30	μmhos
	BCY58-VIII, BCY59-VIII				50	
	BCY58-IX, BCY59-IX				60	
	BCY58-X, BCY59-X				100	
Input Impedance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	BCY58-VII, BCY59-VII	h_{ie} (h_{11e})	1.6		4.5	Kohms
	BCY58-VIII, BCY59-VIII		2.5		6	
	BCY58-IX, BCY59-IX		3.2		8.5	
	BCY58-X, BCY59-X		4.5		12	
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = kHz)	BCY58-VII, BCY59-VII	h_{re} (h_{12e})		1.5		$\times 10^{-4}$
	BCY58-VIII, BCY59-VIII			2		
	BCY58-IX, BCY59-IX			2		
	BCY58-X, BCY59-X			3		
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5 Vdc, R_S = 2 Kohms, f = 1 kHz)	all	N_F		2	6	dB
SWITCHING CHARACTERISTICS						
I_C = 10 mA, I_{B1} = 1 mA, I_{B2} = 1 mA, V_{BB} = 3.6 V, R_1 = R_2 = 5 KΩ, R_L = 990 ohms		t_d		35		nS
		t_r		50		
		t_{on}		85	150	
* See test circuit.		t_s		400		
		t_f		80		
		t_{off}		480	800	
I_C = 100 mA, I_{B1} = 10 mA, I_{B2} = 10 mA, V_{BB} = 5 V, R_1 = 500 Ω, R_2 = 700 Ω, R_L = 98 ohms		t_d		5		nS
		t_r		50		
		t_{on}		55	150	
* See test circuit.		t_s		250		
		t_f		200		
		t_{off}		450	800	

TEST CIRCUIT

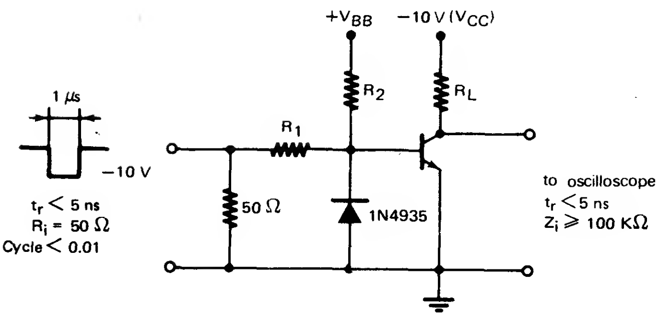


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FIGURE 1 – CURRENT GAIN (BCY58-VII/BCY59-VII)

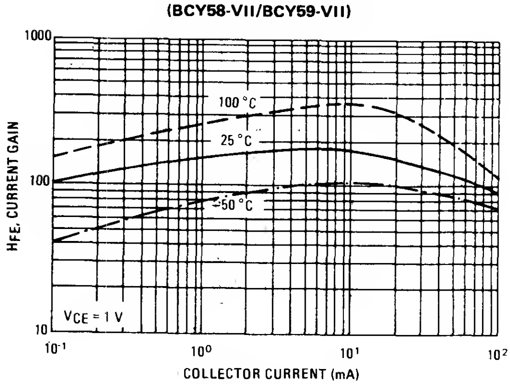

FIGURE 2 – CURRENT GAIN (BCY58-VIII/BCY59-VIII)

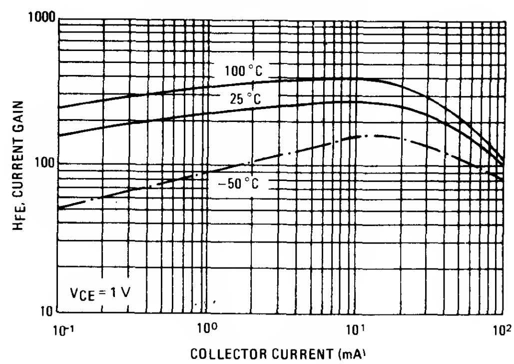

FIGURE 3 – CURRENT GAIN (BCY58-IX/BCY59-IX)

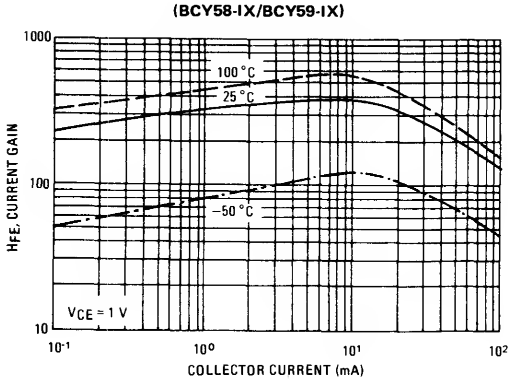

FIGURE 4 – CURRENT GAIN (BCY58-X/BCY59-X)

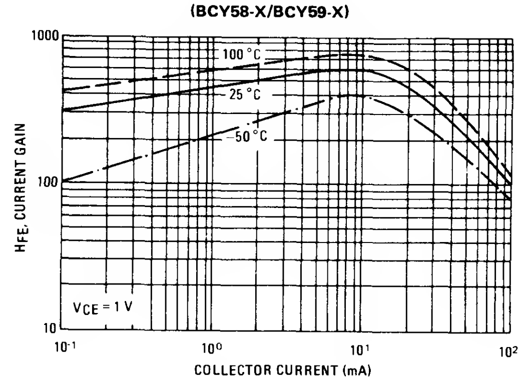

FIGURE 5 – SATURATION VOLTAGE

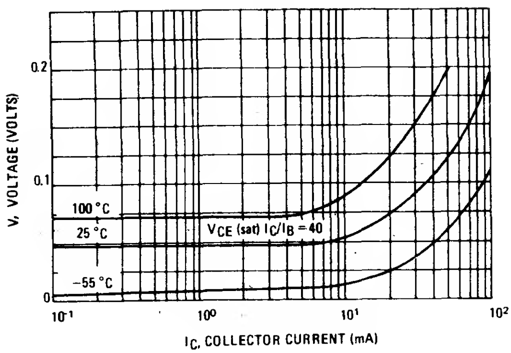

FIGURE 6 – SATURATION VOLTAGE

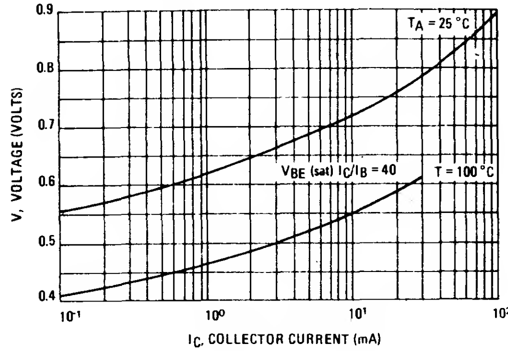

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FIGURE 7 – INPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

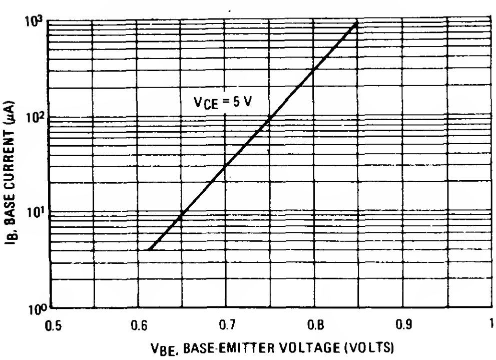

FIGURE 8 – OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

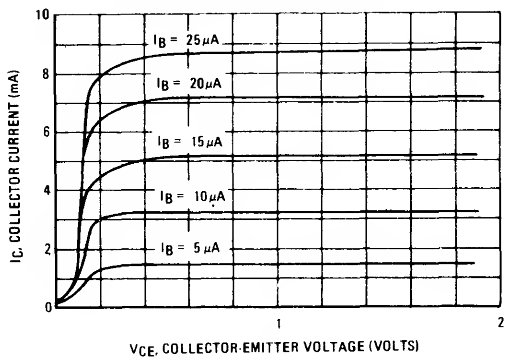

FIGURE 9 – OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

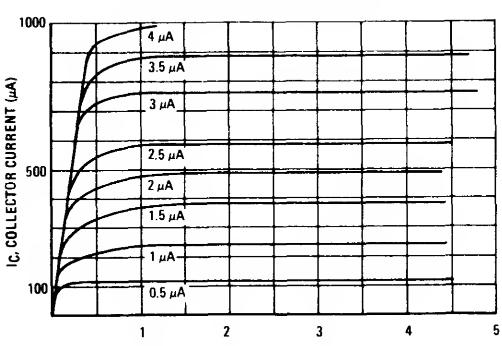

FIGURE 10 – OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

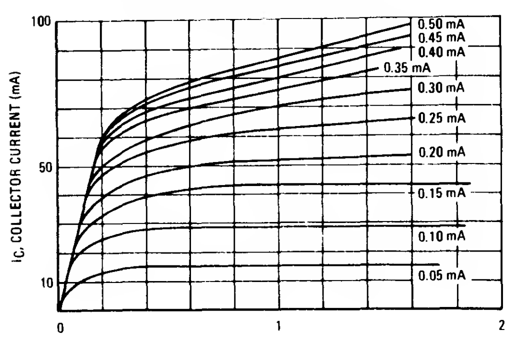

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FIGURE 11 – OUTPUT CHARACTERISTIC (COMMON EMITTER CIRCUIT)

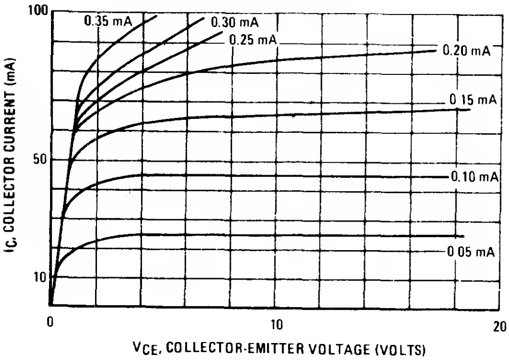


FIGURE 12 – EMITTER-BASE CAPACITANCE COLLECTOR-BASE CAPACITANCE

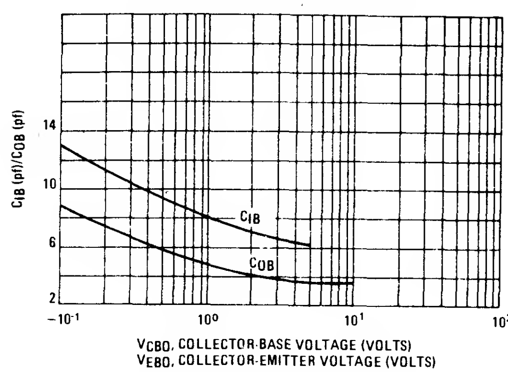


FIGURE 13 – CURRENT GAIN – BANDWIDTH PRODUCT

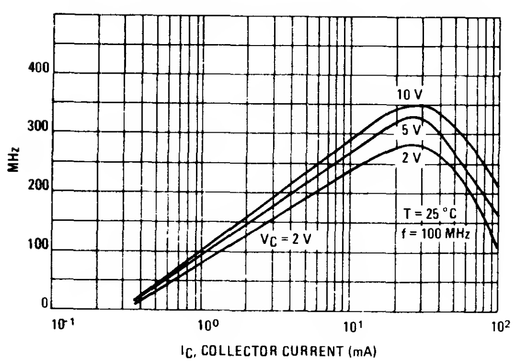
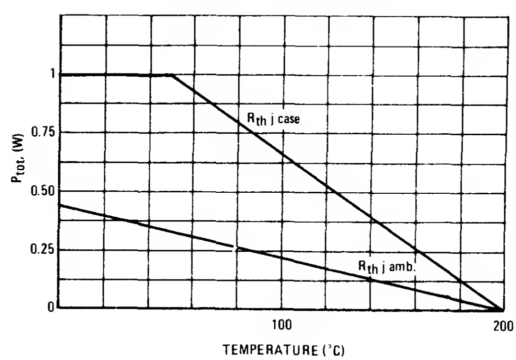


FIGURE 14 – TOTAL PERMISSIBLE POWER DISSIPATION (BCY58/BCY59)



MAXIMUM RATINGS

Rating	Symbol	BCY 70	BCY 71	BCY 72	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	25	Vdc
Collector-Base Voltage	V_{CBO}	50	45	25	Vdc
Emitter-Base Voltage	V_{EBO}	5			Vdc
Collector Current – Continuous	I_C	0.2			Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06			mWatt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	0.6 4.0			mWatt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	175	°C/W

BCY70
BCY71
BCY72

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

TRANSISTOR

PNP SILICON

Refer to 2N3798 for graphs.

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Emitter Breakdown Voltage (I_C = 2 mA, I_B = 0)	BCY70 BCY71 BCY72	$V_{(BR)CEO}$	40 45 25			Vdc
Collector Base Leakage Current (I_E = 0, V_{CB} = 50 V) (I_E = 0, V_{CB} = 45 V) (I_E = 0, V_{CB} = 25 V)	BCY70 BCY71 BCY72	I_{CBO}			0.5 0.5 0.5	μA
(I_E = 0, V_{CB} = 40 V, T_{Amb} = 100°C) (I_E = 0, V_{CB} = 40 V, T_{Amb} = 100°C) (I_E = 0, V_{CB} = 20 V, T_{Amb} = 100°C)	BCY70 BCY71 BCY72				2 2 2	
(I_E = 0, V_{CB} = 40 V) (I_E = 0, V_{CB} = 40 V) (I_E = 0, V_{CB} = 20 V)	BCY70 BCY71 BCY72				10 50 50	nA
Emitter Base Leakage Current (V_{EB} = 5 V, I_C = 0) (V_{EB} = 4 V, I_C = 0) (V_{EB} = 4 V, I_C = 0, T_{Amb} = 100°C)		I_{EBO}			0.5 10 2	μA nA μA
Collector Emitter Leakage Current (V_{CE} = 50 V, V_{BE} = 3 V)	BCY70	I_{CEX}			20	nA
ON CHARACTERISTICS						
DC Current Gain (V_{CE} = 1 V, I_C = 10 μA)	BCY71	HFE	40			
(V_{CE} = 1 V, I_C = 100 μA)	BCY70 BCY71		40 80			
(V_{CE} = 1 V, I_C = 1 mA)	BCY70 BCY71 BCY72		45 90 40			
(V_{CE} = 1 V, I_C = 10 mA)	BCY70 BCY71 BCY72		50 100 50		 600 	
(V_{CE} = 1 V, I_C = 50 mA)	BCY70		15			
Base Emitter Saturation Voltage (I_C = 50 mA, I_B = 5 mA) (I_C = 10 mA, I_B = 1 mA)	BCY70/71 BCY70/71	$V_{BE(sat)}$	 0.6		1.2 0.9	V
Collector Emitter Saturation Voltage (I_C = 50 mA, I_B = 5 mA) (I_C = 10 mA, I_B = 1 mA)		$V_{CE(sat)}$			0.50 0.25	V

4

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS						
Transition Frequency		f_T				MHz
(I_C = 10 mA, f = 100 MHz, V_{CE} = 20 V)	All types		250			
(I_C = 100 µA, f = 10.7 MHz, V_{CE} = 20 V)	BCY71 only		15			
Noise Figure (V_{CE} = 5 V, I_C = 100 µA, Rg = 2 KΩ, 30 to 15 kHz at − 3 dB points)		NF				dB
	BCY70/72				6	
	BCY71				2	
Switching Times (I_C = 10 mA, I_{B1} = I_{B2} = 1 mA)	BCY70/72	ton			65	ns
	BCY70/72	toff			420	
	BCY70/72	td			35	
	BCY70/72	tr			35	
	BCY70/72	ts			350	
	BCY70/72	tf			80	
h parameters (V_{CE} = 10 V, I_C = 1 mA, f = 1 kHz)	BCY71	h_{12e}	—		20×10^{-4}	—
		h_{21e}	100		400	—
		h_{22e}	10		60	µs
		h_{11e}	2		12	KΩ
Common Base Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)		C_{ob}			6	pF
Input Capacitance (V_{BE} = 1 V, I_C = 0, f = 1 MHz		C_{ib}			8	pF

MAXIMUM RATINGS

Rating	Symbol	BCY 78	BCY 79	Unit
Collector-Emitter Voltage	V_{CEO}	32	45	Vdc
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CES}	32	45	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current – Continuous	I_C	0.2		Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 2.28		Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1 6.67		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	150	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	450	°C/W

BCY78
BCY79

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

TRANSISTOR

PNP SILICON

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_C = 0)	BCY78 BCY79	$V_{(BR)CEO}$	32 45			Vdc
Emitter-Base Breakdown Voltage (I_E = 2 µAdc, I_C = 0)	all	$V_{(BR)EBO}$	5			Vdc
Collector Cutoff Current						
(V_{CE} = 32 V)	BCY78	I_{CES}		0.2	100	nA
(V_{CE} = 45 V)	BCY79			0.2	100	
(V_{CE} = 32 V, T_A = 100°C, V_{BE} = 0.2 V)	BCY78	I_{CEX}			20	µAdc
(V_{CE} = 45 V, T_A = 100°C, V_{BE} = 0.2 V)	BCY79				20	
(V_{CE} = 25 V, T_A = 150°)	BCY78	I_{CES}		0.2	10	µAdc
(V_{CE} = 35 V, T_A = 150°)	BCY79			0.5	10	
Emitter Base Cutoff Current (V_{EB} = 4 V)	all	I_{EBO}			20	nA
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = 10 µAdc, V_{CE} = 5 Vdc)	BCY79-VII, BCY78-VII					
	BCY79-VIII, BCY78-VIII		30	145		
	BCY79-IX, BCY78-IX		40	220		
	BCY79-X, BCY78-X		100	300		
(I_C = 2 mAdc, V_{CE} = 5 Vdc)	BCY79-VII, BCY78-VII		120	170	220	
	BCY79-VIII, BCY78-VIII		180	250	310	
	BCY79-IX, BCY78-IX		250	350	460	
	BCY79-X, BCY78-X		380	500	630	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	BCY79-VII, BCY78-VII		80	190		
	BCY79-VIII, BCY78-VIII		120	260	400	
	BCY79-IX, BCY78-IX		160	380	630	
	BCY79-X, BCY78-X		240	550	1000	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	BCY79-VII, BCY78-VII		40			
	BCY79-VIII, BCY78-VIII		45			
	BCY79-IX, BCY78-IX		60			
	BCY79-X, BCY78-X		60			
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 2.5 mAdc) (I_C = 10 mAdc, I_B = 0.25 mA)	all	$V_{CE(sat)}$	0.15 0.05	0.30 0.12	0.80 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.25 mA) (I_C = 100 mA, I_B = 2.5 mA)	all	$V_{BE(sat)}$	0.6 0.75	0.70 0.90	0.85 1.2	Vdc
Base-Emitter on Voltage (I_C = 2 mAdc, V_{CE} = 5 Vdc)	all	$V_{BE(on)}$	0.60	0.62	0.75	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS SMALL SIGNAL CHARACTERISTICS						
Current Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 V, f = 100 MHz)	all	f_T	180	300		MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1 MHz)	all	C_{ob}		3.5	7	pF
Input Capacitance (V_{BE} = 0.5 V, I_C = 0, f = 1 MHz)	all	C_{ib}		8	15	pF
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	BCY78-VII, BCY79-VII BCY78-VIII, BCY79-VIII BCY78-IX, BCY79-IX BCY78-X, BCY79-X	h_{fe} (h_{21e})		200 260 330 520		
Input Impedance (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	BCY78-VII, BCY79-VII BCY78-VIII, BCY79-VIII BCY78-IX, BCY79-IX BCY78-X, BCY79-X	h_{ie} (h_{11e})	1.6 2.5 3.2 7.5		4.5 6 8.5 12	Kohms
Voltage Feedback Ratio (I_C = 2 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	BCY78-VII, BCY79-VII BCY78-VIII, BCY79-VIII BCY78-IX, BCY79-IX BCY78-X, BCY79-X	h_{re} (h_{12e})		1.5 2 2 3		$\times 10^{-4}$
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5 Vdc, R_S = 2 Kohms, f = 1 kHz)	all	N_F		2	6	dB
SWITCHING CHARACTERISTICS						
I_C = 10 mA, I_{B1} = 1 mA, I_{B2} = 1 mA V_{BB} = 3.6 V, R_1 = R_2 = 5 KΩ R_L = 990 ohms * See test circuit.		t_d t_r t_{on} t_s t_f t_{off}		35 50 85 400 80 480	 150 800	nS
I_C = 100 mA, I_{B1} = 10 mA, I_{B2} = 10 mA V_{BB} = 5 V, R_1 = 500 Ω, R_2 = 700 Ω R_L = 98 ohms * See test circuit.		t_d t_r t_{on} t_s t_f t_{off}		5 50 55 250 200 450	 150 800	nS

4

TEST CIRCUIT

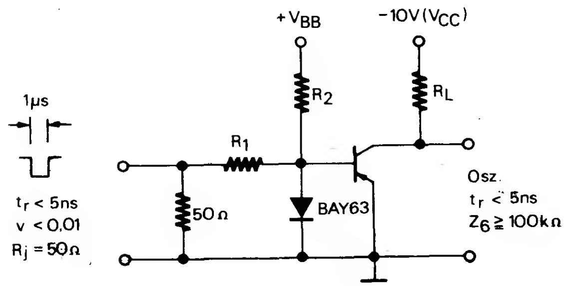


FIGURE 1 – CURRENT GAIN (BCY78-VII/BCY79-VII)

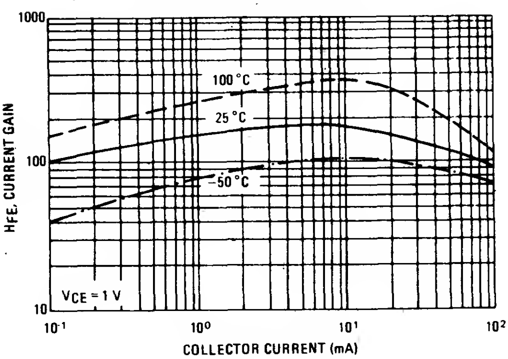


FIGURE 2 – CURRENT GAIN (BCY78-VIII/BCY79-VIII)

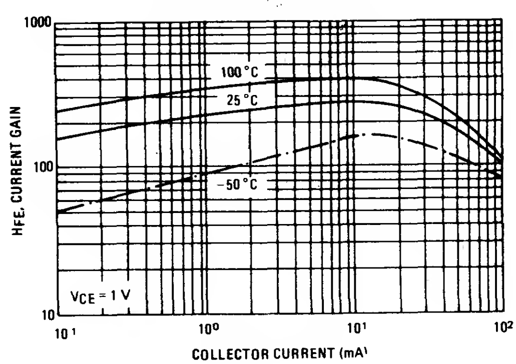


FIGURE 3 – CURRENT GAIN (BCY78-IX/BCY79-IX)

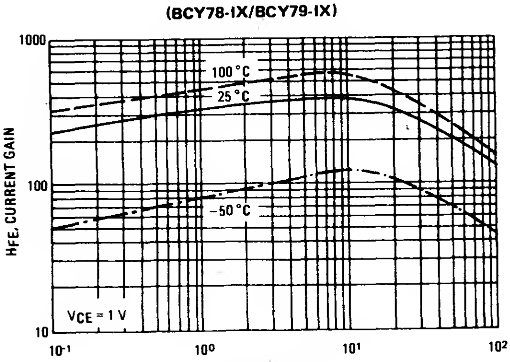


FIGURE 4 – CURRENT GAIN (BCY78-X/BCY79-X)

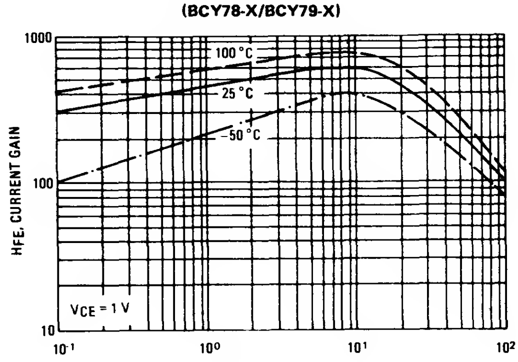


FIGURE 5 – SATURATION VOLTAGE

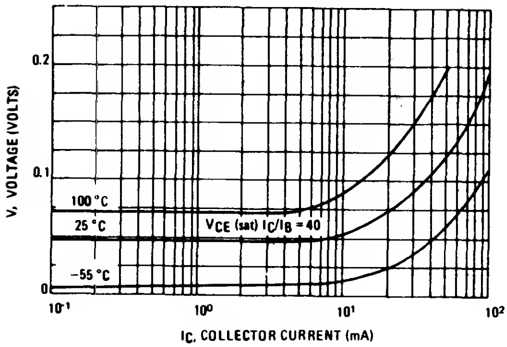


FIGURE 6 – SATURATION VOLTAGE

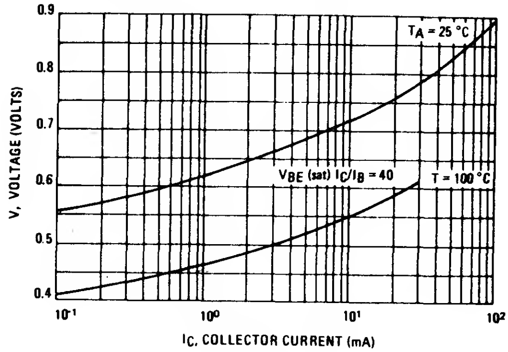


FIGURE 7 – INPUT CHARACTERISTIC
(COMMON EMITTER CIRCUIT)

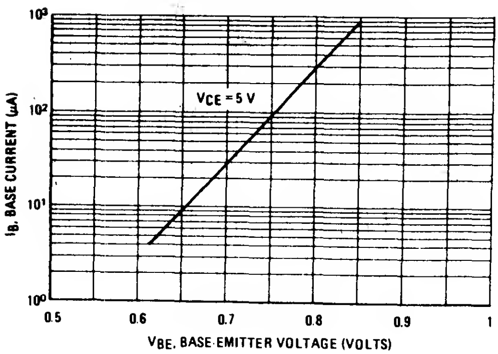


FIGURE 8 – TOTAL PERMISSIBLE POWER
DISSIPATION (BCY78/BCY79)

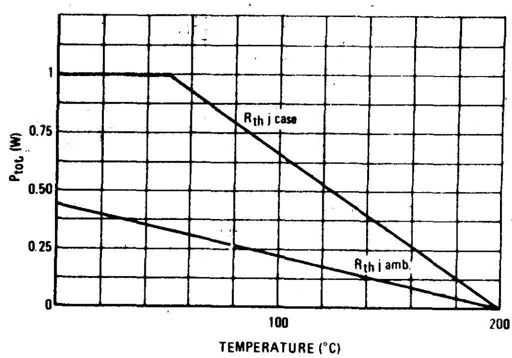


FIGURE 9 – CURRENT GAIN
BANDWIDTH PRODUCT

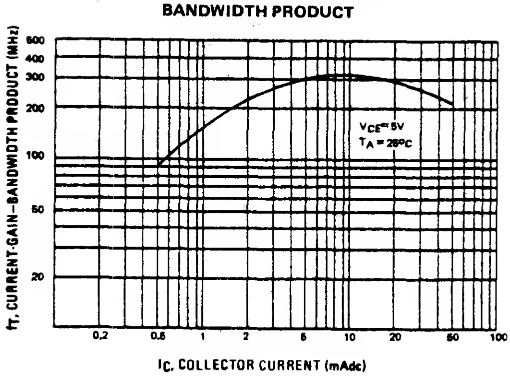
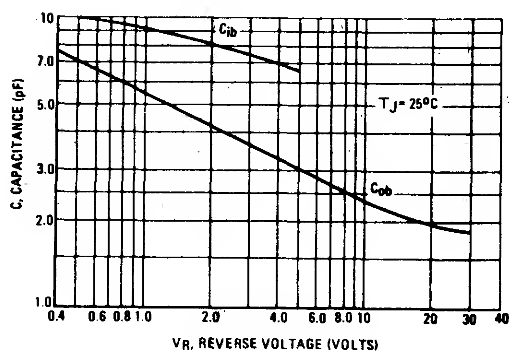


FIGURE 10 – CAPACITANCES



BF257
BF258
BF259

CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BF 257	BF 258	BF 259	Unit
Collector-Emitter Voltage	V_{CEO}	160	250	300	Vdc
Collector-Emitter Voltage	V_{CER}	160	250	300	Vdc
Collector-Base Voltage	V_{CBO}	160	250	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current – Continuous	I_C	0.1			Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57			Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 30$ mAdc, $I_B = 0$)	BF257 BF258 BF259	$V_{(BR)CEO}$	160 250 300	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	BF257 BF258 BF259	$V_{(BR)CBO}$	160 250 300	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 250$ Vdc, $I_E = 0$)	BF257 BF258 BF259	I_{CBO}	— — —	1 1 1	50 50 50	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25	80	—	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 6.0$ mAdc)		$V_{CE(sat)}$	—	0.1	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current Gain Bandwidth Product ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	—	110	—	MHz
Reverse Transfer Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, f = 500 kHz)		C_{re}	—	3.5	—	pF
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 500 kHz)		C_{cb}	—	5.5	—	pF

BFW43

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

BFW44

CASE 79, STYLE 1
TO-39 (TO-205AD)

4

HIGH VOLTAGE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BFW 43	BFW 44	Unit
Collector-Emitter Voltage	V_{CEO}	150	150	Vdc
Collector-Base Voltage	V_{CBO}	150	150	Vdc
Emitter-Base Voltage	V_{EBO}	6	6	Vdc
Collector Current – Continuous	I_C	0.1		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.4 2.66	0.7 4.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.4 8.0	2.5 14.3	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max		Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	438	250	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2 mA, I_B = 0)	$V_{(BR)CEO}$	150			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	150			Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	6			Vdc
Collector Cutoff Current (V_{CB} = 100 V, I_E = 0)	I_{CBO}			10	nA
Collector-Emitter Cutoff Current (V_{CB} = 100 V, I_B = 0) T_A = 125°C	I_{CEO}			10	μA
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V) (I_C = 10 μA, V_{CE} = 10 V, T_A = −55°C)	h_{FE}	 40 40 	 30		
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$		0.15	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$		0.7	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)	f_T	60	110	200	MHz
Output Capacitance (I_E = 0, V_{CB} = 20 Vdc, f = 1 MHz)	C_{obo}	—	3.5	7	pF
Turn On Time (I_{B1} = 10 mA, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{on}	—	100	—	ns
Turn Off Time (I_{B2} = 10 mAdc, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{off}	—	400	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 1 – CURRENT-GAIN–BANDWIDTH PRODUCT

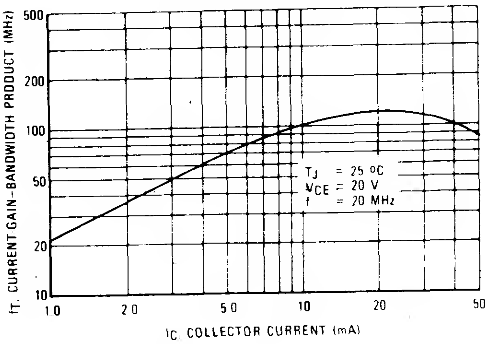


FIGURE 2 – TURN-ON TIME

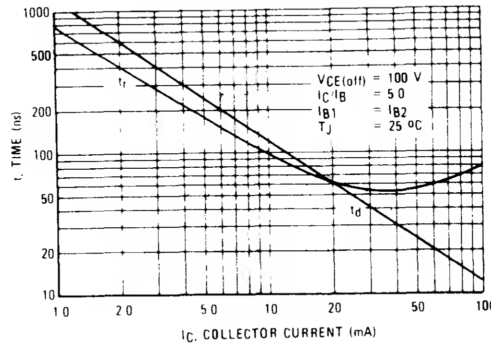


FIGURE 3 – TURN-OFF TIME

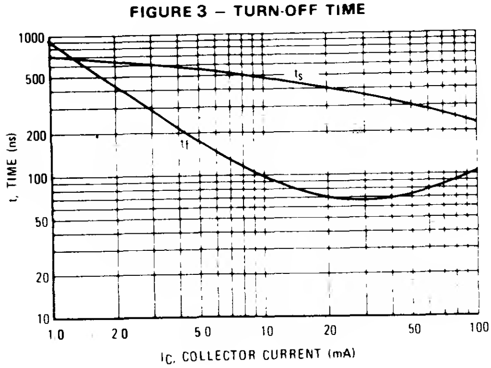
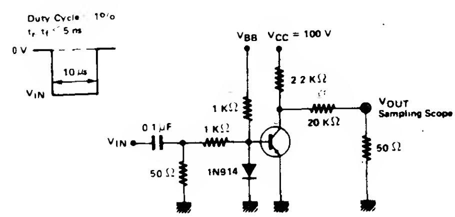


FIGURE 4 – SWITCHING TIME TEST CIRCUIT



	V_{IN}	V_{BB}
T_{ON}	−10.6V	
T_{OFF}	−20V	+9.2V

BFX38,39,40,41

CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH CURRENT TRANSISTOR

PNP SILICON

Refer to 2N4405 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	BFX38 BFX39	BFX40 BFX41	Unit
Collector-Emitter Voltage	V_{CEO}	55	75	Vdc
Collector-Base Voltage	V_{CBO}	55	75	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current – Continuous	I_C	1		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7 40		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA)(1)	BFX38-39 BFX40-41	$V_{(BR)CEO}$	55 75		V
Collector-Base Breakdown Voltage (I_C = 10 μA)	BFX38-39 BFX40-41	$V_{(BR)CBO}$	55 75		V
Emitter-Base Breakdown Voltage (I_E = 10 μA)		$V_{(BR)EBO}$	5		V
Collector Cutoff Current (V_{CB} = 40 V) (V_{CB} = 50 V) (V_{CB} = 40 V, T_A = 125°C) (V_{CB} = 50 V, T_A = 125°C)	BFX38-39 BFX40-41 BFX38-39 BFX40-41	I_{CBO}		50 50 50 50	nA μA
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA)(1) (I_C = 500 mA, I_B = 50 mA)(1)		$V_{CE(sat)}$		0.15 0.5	V
DC Current Gain (I_C = 100 μA, V_{CE} = 5 V)(1)	BFX38-40 BFX39-41	h_{FE}	60 30		
(I_C = 100 mA, V_{CE} = 5 V)(1)	BFX38-40 BFX39-41		85 40		
(I_C = 500 mA, V_{CE} = 5 V)(1)	BFX38-40 BFX39-41		60 25		
(I_C = 1 A, V_{CE} = 5 V)(1)	BFX38 BFX39 BFX40 BFX41		30 15 25 10		
Emitter-Base Saturation Voltage (I_C = 150 mA, I_B = 15 mA)(1) (I_C = 500 mA, I_B = 15 mA)(1)		$V_{BE(sat)}$		0.9 1.1	V
DC Current Gain (I_C = 100 mA, V_{CE} = 5 V, T_A = 125°C)(1)	BFX38-40 BFX39-41	h_{FE}	30 15		

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Current Gain — Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 100 MHz)	f_T	100		MHz
Output Capacitance (V_{CB} = 10 V)	C_{ob}		20	pF
Input Capacitance (V_{EB} = 0.5 V)	C_{ib}		120	pF
Turn On Time (I_C = 500 mA, I_{B1} = 50 mA)	t_{on}		100	ns
Turn Off Time (I_C = 500 mA, I_{B1} = I_{B2} = 50 mA)	t_{off}		350	ns
Fall Time (I_C = 500 mA, I_{B1} = I_{B2} = 50 mA)	t_f		50	ns

4

BFX48

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

4

Refer to 2N869A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current – Continuous	I_C	0.1	Amp
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ $T_C = 100°C$ Derate above 25°C	P_D	1.2 0.686 6.86	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)(1)	$V_{(BR)CEO}$	30		V
Collector-Base Breakdown Voltage (I_C = 10 μA)	$V_{(BR)CBO}$	30		V
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	5		V
Collector Cutoff Current (V_{CE} = 20 V) (V_{CE} = 20 V, T_A = 125°C)	I_{CES}		15 15	nA μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 μA, V_{CE} = 1 V) (I_C = 100 μA, V_{CE} = 1 V) (I_C = 10 mA, V_{CE} = 1 V) (I_C = 50 mA, V_{CE} = 1 V) (I_C = 10 mA, V_{CE} = 1 V, T_A = −55°C)	h_{FE}	40 70 90 20 30		
Collector-Emitter Saturation Voltage (I_C = 1 mA, I_B = 0.1 mA) (I_C = 10 mA, I_B = 1 mA) (I_C = 50 mA, I_B = 5 mA)(1)	$V_{CE(sat)}$		0.13 0.14 0.3	V
Emitter-Base Saturation Voltage (I_C = 1 mA, I_B = 0.1 mA) (I_C = 10 mA, I_B = 1 mA) (I_C = 50 mA, I_B = 5 mA)(1)	$V_{BE(sat)}$		0.75 0.9 1.1	V
SMALL SIGNAL CHARACTERISTICS				
Current Gain — Bandwidth Product (I_C = 10 mA, V_{CE} = 20 V, f = 100 MHz)	f_T	400		MHz
Output Capacitance (V_{CB} = 10 V)	C_{ob}		3.5	pF
Input Capacitance (V_{EB} = 0.5 V)	C_{ib}		5.5	pF
Noise Figure (I_C = 1 mA, V_{CE} = 20 V, f = 100 MHz)	NF		6	dB
Turn On Time (I_C = 50 mA, I_{B1} = 5 mA)	t_{on}		50	ns
Turn Off Time (I_C = 50 mA, I_{B1} = I_{B2} = 5 mA)	t_{off}		160	ns
Collector-Base Time Constant (I_C = 10 mA, V_{CE} = 20 V, f = 80 MHz)	$r_{b'}C_c$		40	ps

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

BFX85

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current − Continuous	I_C	1.0	Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	220	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	$V_{(BR)CEO}$	60		Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_B = 0)	$V_{(BR)CBO}$	100		Vdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0, T_j = 100°C) (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_j = 100°C)	I_{CBO}		50 2.5 500 2.5	nAdc μAdc nAdc μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0) (V_{EB} = 5 Vdc, I_C = 0, T_j = 100°C) (V_{EB} = 6 Vdc, I_C = 0)	I_{EBO}		50 2.5 500	nAdc μAdc nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 Adc, V_{CE} = 10 Vdc)	h_{FE}	50 70 30 15		
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$		0.15 0.35 1.00 1.60	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$		1.2 1.3 1.5 2.0	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 35 MHz)	f_T	50		MHz
Collector Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{obo}		12	pF
Small Signal Current Gain (I_C = 1 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	20 25		
Input Impedance (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	h_{ie}		750	Ω
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	h_{re}		5.0	$\times 10^{4}$
Output Admittance (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	h_{oe}		80	μmhos

4

BFY50
BFY51
BFY52

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BFY 50	BFY 51	BFY 52	Unit
Collector-Emitter Voltage	V_{CEO}	35	30	20	Vdc
Collector-Base Voltage	V_{CBO}	80	60	40	Vdc
Emitter-Base Voltage	V_{EBO}		6		Vdc
Collector Current – Continuous	I_C		1		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		0.8 4.6		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		5 28.6		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	16.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	89.5	°C/W

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	BFY50 BFY51 BFY52	$V_{(BR)CEO}$	35 30 20		V
Collector-Base Breakdown Voltage (I_C = 10 μA)	BFY50 BFY51 BFY52	$V_{(BR)CBO}$	80 60 40		V
Emitter-Base Breakdown Voltage (I_E = 10 μA)		$V_{(BR)EBO}$	6		V
Collector Cutoff Current (V_{CB} = 60 V) (V_{CB} = 40 V) (V_{CB} = 30 V)	BFY50 BFY51 BFY52	I_{CBO}		50	nA
Collector Cutoff Current (V_{CB} = 60 V, T_j = 100°C) (V_{CB} = 40 V, T_j = 100°C) (V_{CB} = 30 V, T_j = 100°C)	BFY50 BFY51 BFY52	I_{CBO}		2.5	μA
Emitter Cutoff Current (V_{EB} = 5 V) (V_{EB} = 5 V, T_j = 100°C)		I_{EBO}		50 2.8	nA μA
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mA, V_{CE} = 6 V) (I_C = 150 mA, V_{CE} = 6 V) (I_C = 1 A, V_{CE} = 6 V)	BFY50 BFY51-52 BFY50 BFY51 BFY52	h_{FE}	20 30 30 40 60 15		
Collector-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA(1) (I_C = 1 A, I_B = 100 mA(1)	BFY50 BFY51-52 BFY50 BFY51-52	$V_{CE(sat)}$		0.2 0.35 1 1.6	V
Emitter-Base Saturation Voltage (I_C = 1 A, I_B = 100 mA(1)		$V_{BE(sat)}$		2	V

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS					
Small Signal Current Gain (I_C = 1 mA, V_{CE} = 6 V, f = 1 kHz)	BFY50 BFY51-52	h_{fe}	10 30		
Output Capacitance (V_{CB} = 12 V, f = 500 kHz)		C_{ob}		12	pF
Current Gain Bandwidth Product (I_C = 50 mA, V_{CE} = 6 V, f = 20 MHz)	BFY50 BFY51-52	f_T	60 50		MHz

4

BSS50
BSS51
BSS52

CASE 79, STYLE 1
TO-39 (TO-205AD)

DARLINGTON TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BSS 50	BSS 51	BSS 52	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	Vdc
Collector-Emitter Voltage	V_{CER}	45	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current − Continuous	I_C	1.0			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 5.3			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5 28.6			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

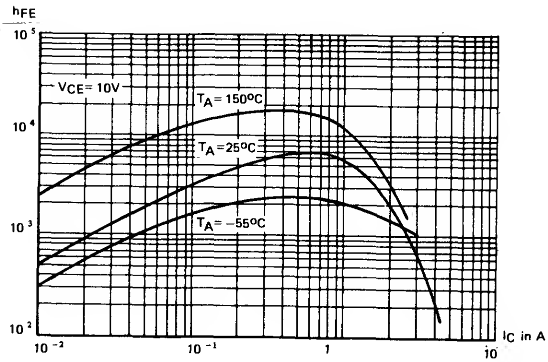
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	220	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Cutoff Current (V_{CB} = 45 V, I_E = 0) (V_{CB} = 60 V, I_E = 0) (V_{CB} = 80 V, I_E = 0)	 BSS50 BSS51 BSS52	I_{CBO}			 50 50 50	nA
Emitter-Cutoff Current (V_{EB} = 4 V, I_C = 0)		I_{EBO}			50	nA
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	 BSS50 BSS51 BSS52	$V_{(BR)CEO}$	 45 60 80			V
Emitter-Base Breakdown Voltage (I_B = 100 µA, I_C = 0)		$V_{(BR)EBO}$	5			V
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 150 mA, V_{CE} = 10 V) (I_C = 500 mA, V_{CE} = 10 V)		h_{FE}	 1500 2000			
Base-Emitter Voltage(1) (I_C = 150 mA, V_{CE} = 10 V) (I_C = 500 mA, V_{CE} = 10 V)		$V_{BE(on)}$	 1.4 1.5		 1.55 1.65	V
Saturation Voltage(1) (I_C = 500 mA, I_B = 0.5 mA) (I_C = 500 mA, I_B = 0.5 mA) (I_C = 1 A, I_B = 1 mA) (I_C = 1 A, I_B = 1 mA) (I_C = 1 A, I_B = 4 mA) (I_C = 1 A, I_B = 4 mA)	 BSS51 BSS51 BSS50-52 BSS50-52	 $V_{CE(sat)}$ $V_{BE(sat)}$ $V_{CE(sat)}$ $V_{BE(sat)}$ $V_{CE(sat)}$ $V_{BE(sat)}$			 1.3 1.9 1.6 2.2 1.6 2.2	V
DYNAMIC CHARACTERISTICS						
Current Gain Bandwidth Product (I_C = 500 mA, V_{CE} = 5, f = 20 MHz)		f_T		70		MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)		C_{ob}		11	25	pf
Turn On Time (I_C = 500 mA, I_{B1} = $-I_{B2}$ = 0.5 mA) Turn Off Time (I_C = 500 mA, I_{B1} = $-I_{B2}$ = 0.5 mA)		t_{on} t_{off}		400 1500		ns

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle = 2%, unless otherwise specified.

FIGURE 1 — CURRENT GAIN versus COLLECTOR CURRENT



BSS60
BSS61
BSS62

CASE 79, STYLE 1
TO-39 (TO-205AD)

DARLINGTON TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BSS 60	BSS 61	BSS 62	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	Vdc
Collector-Emitter Voltage	V_{CER}	45	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current – Continuous	I_C	1.0			Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 5.3			Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5 28.6			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	220	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Cutoff Current ($V_{CB} = 45$ V, $I_E = 0$) ($V_{CB} = 60$ V, $I_E = 0$) ($V_{CB} = 80$ V, $I_E = 0$)	 BSS60 BSS61 BSS62	I_{CBO}			 50 50 50	nA
Emitter-Cutoff Current ($V_{EB} = 4$ V, $I_C = 0$)		I_{EBO}			100	nA
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA, $I_B = 0$)	 BSS60 BSS61 BSS62	$V_{(BR)CEO}$	 45 60 80			V
Emitter-Base Breakdown Voltage ($I_B = 100\ \mu A$, $I_C = 0$)		$V_{(BR)EBO}$	5			V
ON CHARACTERISTICS						
DC Current Gain(1) ($I_C = 150$ mA, $V_{CE} = 10$ V) ($I_C = 500$ mA, $V_{CE} = 10$ V)		h_{FE}	 1500 2000			
Saturation Voltage(1) ($I_C = 500$ mA, $I_B = 0.5$ mA) ($I_C = 500$ mA, $I_B = 0.5$ mA) ($I_C = 1$ A, $I_B = 1$ mA) ($I_C = 1$ A, $I_B = 1$ mA) ($I_C = 1$ A, $I_B = 4$ mA) ($I_C = 1$ A, $I_B = 4$ mA)	 BSS61 BSS61 BSS60-62 BSS60-62	 $V_{CE(sat)}$ $V_{BE(sat)}$ $V_{CE(sat)}$ $V_{BE(sat)}$ $V_{CE(sat)}$ $V_{BE(sat)}$			 1.3 1.9 1.6 2.2 1.6 2.2	V
DYNAMIC CHARACTERISTICS						
Current Gain Bandwidth Product ($I_C = 500$ mA, $V_{CE} = 5$ V, f = 20 MHz)		f_T		70		MHz
Output Capacitance ($V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz)		C_{ob}			25	pf
Turn On Time ($I_C = 500$ mA, $I_{B1} = -I_{B2} = 0.5$ mA) Turn Off Time ($I_C = 500$ mA, $I_{B1} = -I_{B2} = 0.5$ mA)		t_{on} t_{off}		400 1500		ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%, unless otherwise specified.

BSS71
BSS72
BSS73

CASE 79, STYLE 1
TO-18 (TO-206AA)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BSS 71	BSS 72	BSS 73	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	300	Vdc
Collector-Base Voltage	V_{CBO}	200	250	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current – Continuous	I_C	0.5			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 14.3			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	70	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	BSS71 BSS72 BSS73	$V_{(BR)CEO}$	200 250 300	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BSS71 BSS72 BSS73	$V_{(BR)CBO}$	200 250 300	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BSS71 BSS72 BSS73	$V_{(BR)EBO}$	6 6 6	— — —	— — —	Vdc
Collector Cutoff Current (V_{CB} = 150 V, I_E = 0) (V_{CB} = 200 V, I_E = 0) (V_{CB} = 250 V, I_E = 0)	BSS71 BSS72 BSS73	I_{CBO}	— — —	— — —	50 50 50	nA
Collector-Emitter Cutoff Current (V_{CE} = 150 V, I_B = 0) (V_{CE} = 200 V, I_B = 0) (V_{CE} = 300 V, I_B = 0)	BSS71 BSS72 BSS73	I_{CEO}	— — —	— — —	500 500 500	nA
Emitter-Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)	ALL	I_{EBO}	—	—	50	nA
ON CHARACTERISTICS(1)						
DC Current Gain (I_C = 0.1 mA, V_{CE} = 1 V) (I_C = 1 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V) (I_C = 30 mA, V_{CE} = 10 V) (I_C = 100 mA, V_{CE} = 10 V)	BSS71 ALL ALL ALL BSS73	h_{FE}	20 30 50 40 —	40 45 120 140 35	— — — 250 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 30 mAdc, I_B = 3 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 20 mAdc)	ALL ALL ALL BSS73	$V_{CE(sat)}$	— — — —	0.15 0.25 0.35 0.25	0.3 0.4 0.5 —	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 30 mAdc, I_B = 3 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	ALL ALL ALL BSS73	$V_{BE(sat)}$	— — — —	0.7 0.8 0.85 0.9	0.8 0.9 1.0 —	Vdc

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_t	50	70	200	MHz
Output Capacitance (I_E = 0, V_{CB} = 20 Vdc, f = 1 MHz)	C_{ob}	—	3.5	—	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1 MHz)	C_{ib}	—	45	—	pF
Turn On Time (I_{B1} = 10 mA, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{on}	—	100	—	ns
Turn Off Time (I_{B2} = 10 mAdc, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{off}	—	400	—	ns

4

FIGURE 1 — DC CURRENT GAIN

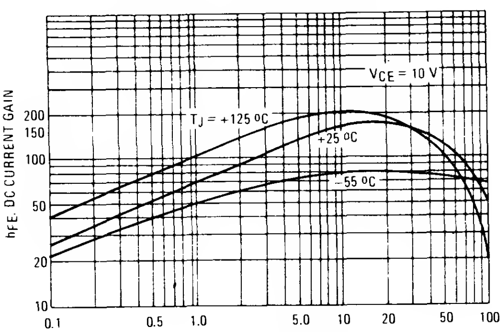


FIGURE 2 — CAPACITANCES

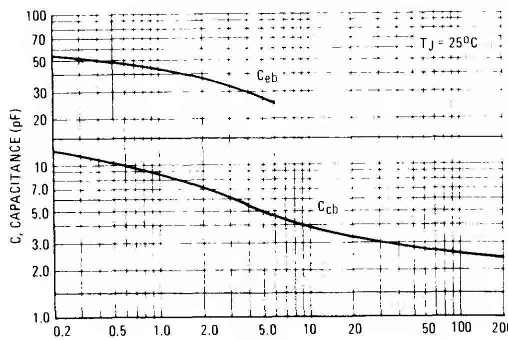


FIGURE 3 — CURRENT-GAIN — BANDWIDTH PRODUCT

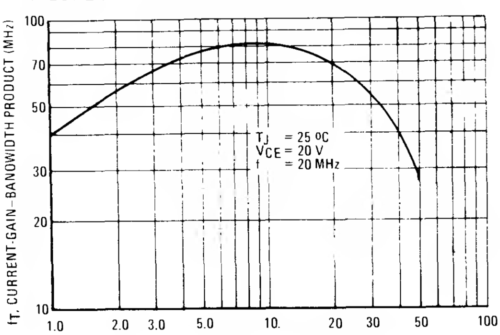
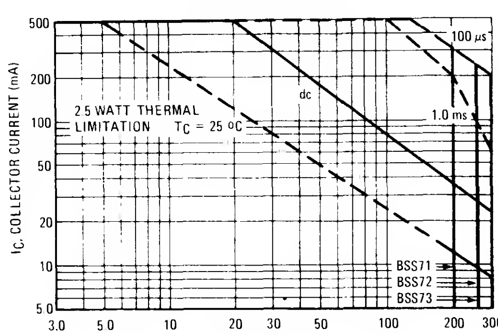


FIGURE 4 — ACTIVE-REGION SAFE OPERATING AREA



4

FIGURE 5 – "ON" VOLTAGES

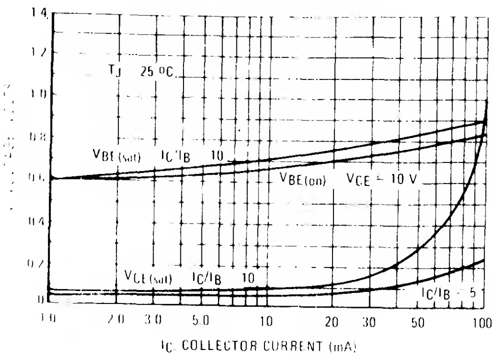


FIGURE 6 – TEMPERATURE COEFFICIENTS

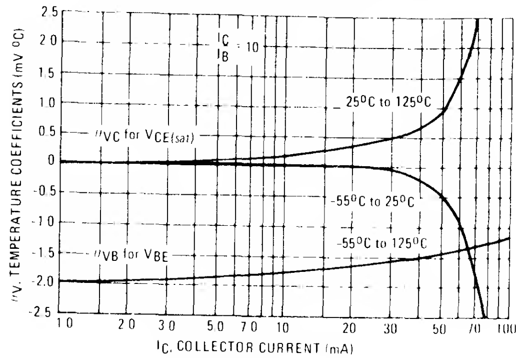


FIGURE 7 – TURN-ON TIME

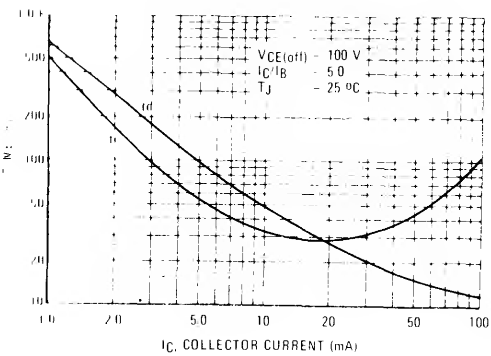


FIGURE 8 – TURN-OFF TIME

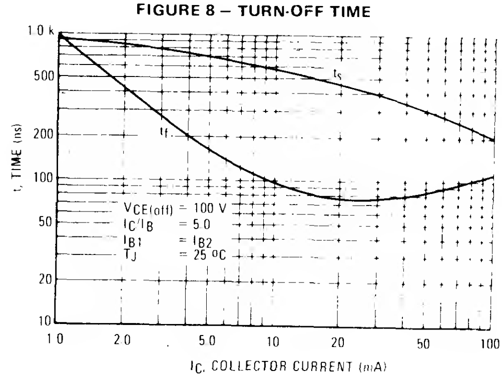
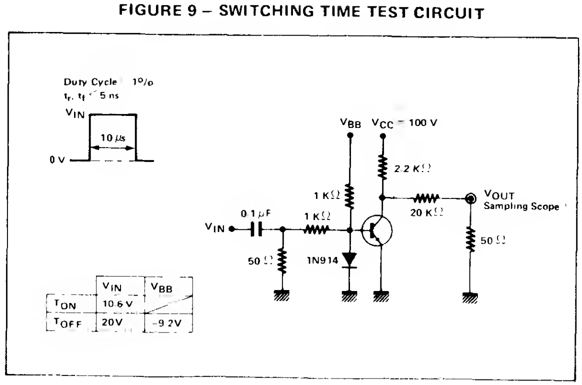


FIGURE 9 – SWITCHING TIME TEST CIRCUIT



BSS74
BSS75
BSS76

CASE 79, STYLE 1
TO-18 (TO-206AA)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BSS 74	BSS 75	BSS 76	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	300	Vdc
Collector-Base Voltage	V_{CBO}	200	250	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current – Continuous	I_C	0.5			Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.86			Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 14.3			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	70	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	BSS74 BSS75 BSS76	$V_{(BR)CEO}$	200 250 300	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BSS74 BSS75 BSS76	$V_{(BR)CBO}$	200 250 300	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BSS74 BSS75 BSS76	$V_{(BR)EBO}$	6 6 6	— — —	— — —	Vdc
Collector Cutoff Current (V_{CB} = 150 V, I_E = 0) (V_{CB} = 200 V, I_E = 0) (V_{CB} = 250 V, I_E = 0)	BSS74 BSS75 BSS76	I_{CBO}	— — —	— — —	50 50 50	nA
Collector-Emitter Cutoff Current (V_{CE} = 150 V, I_B = 0) (V_{CE} = 200 V, I_B = 0) (V_{CE} = 300 V, I_B = 0)	BSS74 BSS75 BSS76	I_{CEO}	— — —	— — —	500 500 500	nA
Emitter-Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)	ALL	I_{EBO}	—	—	50	nA
ON CHARACTERISTICS(1)						
DC Current Gain (I_C = 0.1 mA, V_{CE} = 1 V) (I_C = 1 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V) (I_C = 30 mA, V_{CE} = 10 V) (I_C = 100 mA, V_{CE} = 10 V)	BSS74 ALL ALL ALL BSS76	h_{FE}	20 30 35 35 —	40 45 50 55 40	— — — 150 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 30 mAdc, I_B = 3 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 20 mAdc)	ALL ALL ALL BSS76	$V_{CE(sat)}$	— — — —	0.15 0.25 0.35 0.40	0.3 0.4 0.5 —	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 30 mAdc, I_B = 3 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	ALL ALL ALL BSS76	$V_{BE(sat)}$	— — — —	0.7 0.8 0.85 0.9	0.8 0.9 1.0 —	Vdc

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_t	50	110	200	MHz
Output Capacitance (I_E = 0, V_{CB} = 20 Vdc, f = 1 MHz)	C_{ob}	—	3.5	—	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1 MHz)	C_{ib}	—	45	—	pF
Turn On Time (I_{B1} = 10 mA, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{on}	—	100	—	ns
Turn Off Time (I_{B2} = 10 mAdc, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{off}	—	400	—	ns

4

FIGURE 1 — DC CURRENT GAIN

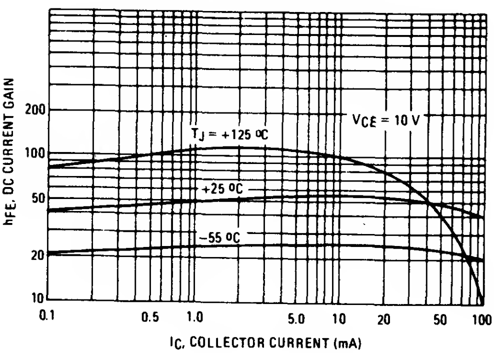


FIGURE 2 — CAPACITANCES

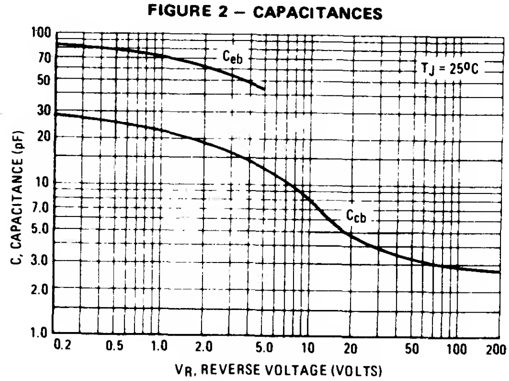


FIGURE 3 — "ON" VOLTAGES

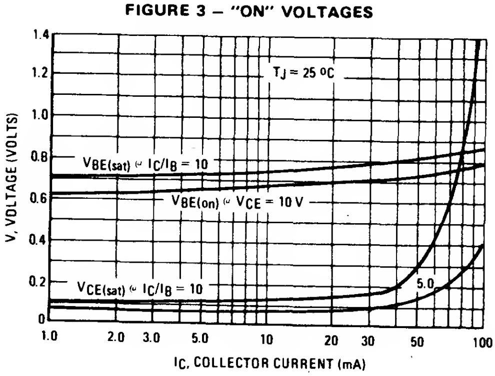


FIGURE 4 — TEMPERATURE COEFFICIENTS

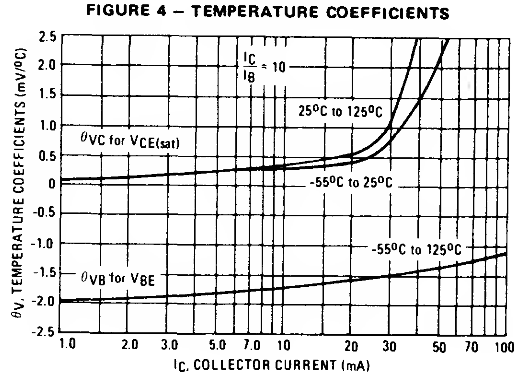


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

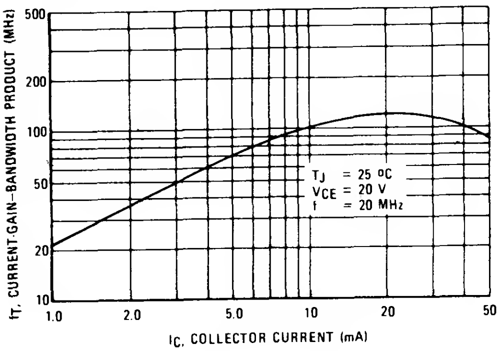


FIGURE 6 – TURN-ON TIME

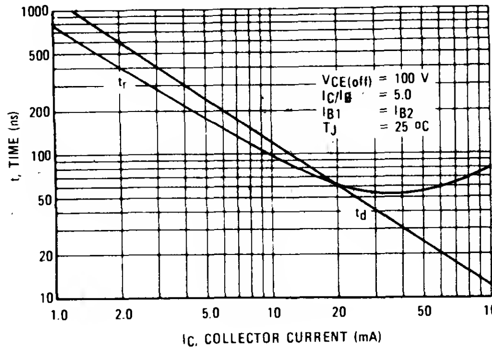


FIGURE 7 – TURN-OFF TIME

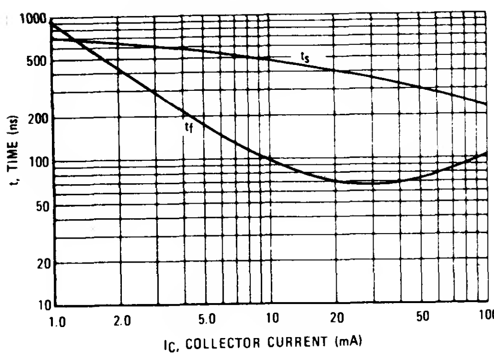


FIGURE 8 – SWITCHING TIME TEST CIRCUIT

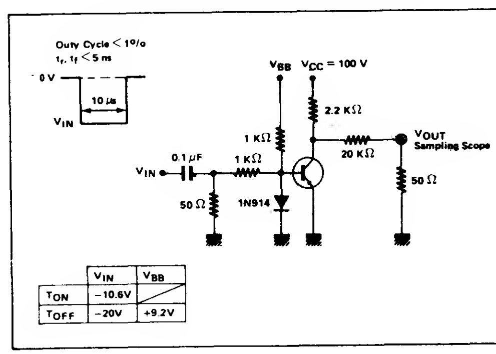
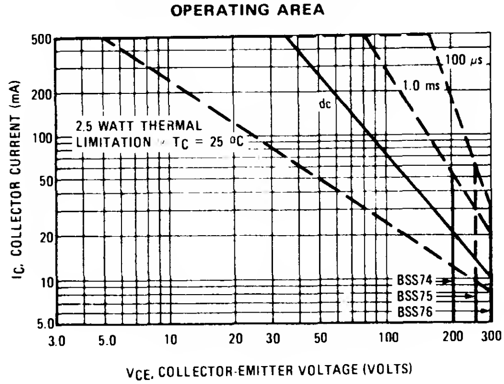


FIGURE 9 – ACTIVE-REGION SAFE OPERATING AREA



BSS77
BSS78

CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BSS 77	BSS 78	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	Vdc
Collector-Base Voltage	V_{CBO}	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	6		Vdc
Collector Current – Continuous	I_C	1		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA, $I_B = 0$)	BSS77 BSS78	$V_{(BR)CEO}$	200 250	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ µAdc, $I_E = 0$)	BSS77 BSS78	$V_{(BR)CBO}$	200 250	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ µAdc, $I_C = 0$)	BSS77 BSS78	$V_{(BR)EBO}$	6 6	— —	— —	Vdc
Collector Cutoff Current ($V_{CB} = 150$ V, $I_E = 0$) ($V_{CB} = 200$ V, $I_E = 0$)	BSS77 BSS78	I_{CBO}	— —	— —	50 50	nA
Collector-Emitter Cutoff Current ($V_{CE} = 150$ V, $I_B = 0$) ($V_{CE} = 200$ V, $I_B = 0$)	BSS77 BSS78	I_{CEO}	— —	— —	500 500	nA
Emitter-Base Cutoff Current ($V_{BE} = 5$ Vdc, $I_C = 0$) ($V_{BE} = 5$ Vdc, $I_C = 0$)	BSS77 BSS78	I_{EBO}	— —	— —	50 50	nA
ON CHARACTERISTICS(1)						
DC Current Gain ($I_C = 0.1$ mA, $V_{CE} = 1$ V) ($I_C = 1$ mA, $V_{CE} = 10$ V) ($I_C = 10$ mA, $V_{CE} = 10$ V) ($I_C = 30$ mA, $V_{CE} = 10$ V) ($I_C = 100$ mA, $V_{CE} = 10$ V)	Both types	h_{FE}	20 30 50 40 —	40 45 120 140 35	— — — 250 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1$ mAdc) ($I_C = 30$ mAdc, $I_B = 3$ mAdc) ($I_C = 50$ mAdc, $I_B = 5$ mAdc) ($I_C = 100$ mAdc, $I_B = 20$ mAdc)	Both types	$V_{CE(sat)}$	— — — —	0.15 0.25 0.35 0.25	0.3 0.4 0.5 —	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1$ mAdc) ($I_C = 30$ mAdc, $I_B = 3$ mAdc) ($I_C = 50$ mAdc, $I_B = 5$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	Both types	$V_{BE(sat)}$	— — — —	0.7 0.8 0.85 0.9	0.8 0.9 1.0 —	Vdc

*Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_t	50	70	200	MHz
Output Capacitance (I_E = 0, V_{CB} = 20 Vdc, f = 1 MHz)	C_{ob}	—	3.5	—	pF
Input Capacitance (I_C = 0, V_{EB} = 0.5 Vdc, f = 1 MHz)	C_{ib}	—	45	—	pF
Turn On Time (I_{B1} = 10 mA, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{on}	—	100	—	ns
Turn Off Time (I_{B2} = 10 mAdc, I_C = 50 mAdc, V_{CC} = 100 Vdc)	t_{off}	—	400	—	ns

BSV15
BSV16
BSV17

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4405 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BSV 15	BSV 16	BSV 17	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Emitter Voltage	V_{CES}	40	60	90	Vdc
Collector-Base Voltage	V_{CBO}	40	60	90	Vdc
Emitter-Base Voltage	V_{EBO}	5			Vdc
Collector Current − Continuous	I_C	1			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7 40			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

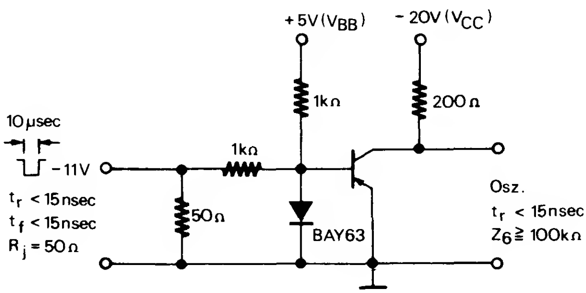
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current		I_{CES}			
(V_{CE} = 40 V)				50	nA
(V_{CE} = 40 V, T_A = 150°C)	BSV15			50	µA
(V_{CE} = 60 V)				50	nA
(V_{CE} = 60 V, T_A = 150°C)	BSV16			50	µA
(V_{CE} = 80 V)				50	nA
(V_{CE} = 80 V, T_A = 150°C)	BSV17			50	µA
(V_{CE} = 40 V, V_{BE} = −0.2 V, T_A = 100°C)	BSV15	I_{CEX}		50	µA
(V_{CE} = 60 V, V_{BE} = −0.2 V, T_A = 100°C)	BSV16			50	
(V_{CE} = 80 V, V_{BE} = −0.2 V, T_A = 100°C)	BSV17			50	
Emitter Cutoff Current (V_{EB} = 4 V)		I_{EBO}		50	nA
Collector-Emitter Breakdown Voltage (I_C = 50 mA(1))	BSV15 BSV16 BSV17	$V_{(BR)CEO}$	40 60 80		V
Collector-Emitter Breakdown Voltage (I_C = 10 µA)	BSV15 BSV16 BSV17	$V_{(BR)CES}$	40 60 90		V
Emitter-Base Breakdown Voltage (I_E = 10 µA)		$V_{(BR)EBO}$	5		V
Emitter Cutoff Current (V_{EB} = 4 V)		I_{EBO}		50	nA
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			
(V_{CE} = 1 V, I_C = 0.1 mA)	BSV15,16,17 − 6		15		
	− 10		20		
	BSV15,16 − 16		30		
(V_{CE} = 1 V, I_C = 100 mA)(1)	BSV15,16,17 − 6		40	100	
	− 10		63	160	
	BSV15,16 − 16		100	250	
(V_{CE} = 1 V, I_C = 500 mA)(1)	BSV15,16,17 − 6		20		
	− 10		25		
	BSV15,16 − 16		35		
Base-Emitter Voltage		$V_{BE(on)}$			V
(V_{CE} = 1 V, I_C = 100 mA)(1)				1	
(V_{CE} = 1 V, I_C = 500 mA)(1)			0.7	1.4	

(1) Pulsed: Pulse Duration = 300 µs, Duty Cycle = 1%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 20 MHz)	f_T	50		MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}		25	pF
Small Signal Current Gain (I_C = 1 mA, V_{CE} = 5 V, f = 1 MHz)	h_{fe}	20		
Turn On Time (Fig. 1) (I_C = 100 mA, I_{B1} = I_{B2} = 5 mA) Storage Time (Fig. 1) (I_C = 100 mA, I_{B1} = I_{B2} = 5 mA)	t_{on} t_s		500 500	ns
Fall Time (Fig. 1) (I_C = 100 mA, I_{B1} = I_{B2} = 5 mA)	t_f		150	ns

FIGURE 1 — SWITCHING TIME CIRCUIT



BSW66A
BSW67A
BSW68A

CASE 79, STYLE 1
TO-39 (TO-205AD)

TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	BSW 66A	BSW 67A	BSW 68A	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	150	Vdc
Collector-Base Voltage	V_{CBO}	100	120	150	Vdc
Emitter-Base Voltage	V_{EBO}	6.0			Vdc
Collector Current − Continuous	I_C	2.0			Amp
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57			Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	220	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BSW66A BSW67A BSW68A	$V_{(BR)CEO}$	100 120 150		Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc)	BSW66A BSW67A BSW68A	$V_{(BR)CBO}$	100 120 150		Vdc
Collector-Base Cutoff Current (V_{CB} = 50 V, I_E = 0) (V_{CB} = 60 V, I_E = 0) (V_{CB} = 75 V, I_E = 0) (V_{CB} = 50 V, I_E = 0, T_j = 150°C) (V_{CB} = 60 V, I_E = 0, T_j = 150°C) (V_{CB} = 75 V, I_E = 0, T_j = 150°C)	BSW66A BSW67A BSW68A BSW66A BSW67A BSW68A	I_{CBO}		100 100 100 100 100 100	nAdc μAdc
Emitter-Base Cutoff Current (V_{EB} = 3 V, I_C = 0) (V_{EB} = 6 V, I_C = 0)		I_{EBO}		100 100	nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mA, V_{CE} = 5 V) (I_C = 100 mA, V_{CE} = 5 V) (I_C = 500 mA, V_{CE} = 5 V) (I_C = 1.0 A, V_{CE} = 5 V)		h_{FE}	30 40 30 15		
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA) (I_C = 500 mA, I_B = 50 mA) (I_C = 1.0 A, I_B = 150 mA)		$V_{CE(sat)}$		0.15 0.40 1.0	Vdc
Emitter-Base Saturation Voltage (I_C = 100 mA, I_B = 10 mA) (I_C = 500 mA, I_B = 50 mA) (I_C = 1.0 A, I_B = 150 mA)		$V_{BE(sat)}$		0.9 1.1 1.4	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 100 mA, V_{CE} = 20 V, f = 35 MHz)		f_t	50		MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)		C_{obo}		20	pF
Input Capacitance (V_{EB} = 0, I_C = 0, f = 1 MHz)		C_{ibo}		300	pF

BSX20

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current – Continuous	I_C		mAmp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mWatt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.2 6.85	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0) (I_C = 10 mAdc, R_{BE} = 10 Ω)	$V_{(BR)CEO}$ $V_{(BR)CER}$	 15 20		Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5		Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_j = 150°C)	I_{CBO}		 400 30	 nAdc μAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_j = 55°C) (V_{CE} = 40 Vdc, V_{BE} = 0)	I_{CES}		 0.4 1.0	μAdc
Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = −3 V, T_j = 55°C)	I_{CEX} I_{BEX}		0.6 0.6	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc, T_j = −55°C) (I_C = 100 mAdc, V_{CE} = 2 Vdc)	h_{FE}	 40 20 10	 120	
Base-Emitter On Voltage (I_C = 30 μAdc, V_{CE} = 20 Vdc, T_j = 100°C)	$V_{BE(on)}$		0.35	Vdc
Emitter-Collector Saturation Voltage (I_C = 10 mAdc, I_B = 0.3 mAdc) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$		 0.3 0.25 0.60	Vdc
Emitter-Base Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 0.7	 0.85 1.50	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 10 V)	f_T	500		MHz
Output Capacitance (V_{CB} = 5 V, I_E = 0, f = 1 MHz)	C_{obo}		4	pF
Input Capacitance (V_{EB} = 1 V, I_C = o, f = 1 MHz)	C_{ibo}		4.5	pF
Time (I_C = 10 mA, I_{B1} = I_{B2} = 10 mA)	t_s		13	ns
Turn-On Time (I_C = 10 mA, I_{B1} = 3 mA) (I_C = 100 mA, I_{B1} = 40 mA)	t_{on}		12 7	ns
Turn-Off Time (I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = − 1.5 mA) (I_C = 100 mA, I_{B1} = 40 mA, I_{B2} = − 20 mA)	t_{off}		18 21	ns

4

BSX29

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current − Continuous	I_C	200	Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D 2.06	.36	Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.2 0.686 6.86	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	°C/W

Refer to 2N869A for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)(1)	$V_{(BR)CEO}$	12		V
Collector-Emitter Breakdown Voltage (I_C = 10 µA)	$V_{(BR)CES}$	12		V
Collector-Base Breakdown Voltage (I_C = 10 µA)	$V_{(BR)CBO}$	12		V
Emitter-Base Breakdown Voltage (I_E = 100 µA)	$V_{(BR)EBO}$	4		V
Collector Cutoff Current (V_{CE} = 6 V, V_{BE} = 0) (V_{CE} = 6 V, V_{BE} = 0, T_A = 85°C)	I_{CES}		80 5	nA µA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1 mA) (I_C = 30 mA, I_B = 3 mA) (I_C = 100 mA, I_B = 10 mA)	$V_{CE(sat)}$		0.15 0.2 0.5	V
Emitter-Base Saturation Voltage (I_C = 10 mA, I_B = 1 mA) (I_C = 30 mA, I_B = 3 mA) (I_C = 100 mA, I_B = 10 mA)	$V_{BE(sat)}$	0.78 0.85	0.98 1.2 1.7	V
DC Current Gain (I_C = 10 mA, V_{CE} = 0.3 V)(1) (I_C = 30 mA, V_{CE} = 0.5 V)(1) (I_C = 100 mA, V_{CE} = 1 V)(1)	h_{FE}	25 30 20	 120	
Collector-Emitter Saturation Voltage (I_C = 30 mA, I_B = 3 mA, T_A = 85°C)	$V_{CE(sat)}$		0.4	V
SMALL SIGNAL CHARACTERISTICS				
Small Signal Current Gain (I_C = 30 mA, V_{CE} = 10 V, f = 100 MHz)	h_{fe}	4		
Output Capacitance (V_{CB} = 5 V)	C_{ob}		6	pF
Input Capacitance (V_{EB} = 0.5 V)	C_{ib}		6	pF
Turn On Time (I_C = 30 mA, I_{B1} = 1.5 mA)	t_{on}		60	ns
Turn Off Time (I_C = 30 mA, I_{B1} = I_{B2} = 1.5 mA)	t_{off}		90	ns

*Pulsed: Pulse Duration = 300 µs, Duty Cycle = 1%.

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BSX32

CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N3725 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	6	Vdc
Collector Current – Continuous	I_C	1	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 2.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)(1)	$V_{(BR)CEO}$	40		V
Collector-Base Breakdown Voltage (I_C = 100 μA, I_E = 0)	$V_{(BR)CBO}$	65		V
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)	$V_{(BR)EBO}$	6		V
Collector Cutoff Current (V_{CB} = 50 V, I_E = 0)	I_{CBO}		4	μA
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = 1 V, I_C = 10 mA)(1) (V_{CE} = 1 V, I_C = 100 mA)(1) (V_{CE} = 1 V, I_C = 500 mA)(1) (V_{CE} = 5 V, I_C = 1 A)(1) (V_{CE} = 1 V, I_C = 100 mA, T_A = −55°C)(1) (V_{CE} = 1 V, I_C = 500 mA)(1)	h_{FE}	 30 60 25 20 30 15	 150	
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)(1) (I_C = 500 mA, I_B = 50 mA)(1) (I_C = 1 A, I_B = 100 mA)(1)	$V_{CE(sat)}$		 0.25 0.5 0.85	V
Base-Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)(1) (I_C = 500 mA, I_B = 50 mA((1) (I_C = 1 A, I_B = 100 mA)(1)	$V_{BE(sat)}$		 0.9 1.5 2	V
SMALL SIGNAL CHARACTERISTICS				
Small Signal Current Gain (I_C = 50 mA, V_{CE} = 10 V, f = 100 MHz)	h_{fe}	3		
Output Capacitance (V_{CB} = 10 V)	C_{ob}		10	pF
Input Capacitance (V_{EB} = 0.5 V)	C_{ib}		60	pF
Turn On Time (I_C = 500 mA, I_{B1} = 50 mA)	t_{on}		60	ns
Turn Off Time (I_C = 500 mA, I_{B1} = I_{B2} = 50 mA)	t_{off}		60	ns

*Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

BSX45
BSX46
BSX47

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	BSX 45	BSX 46	BSX 47	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Emitter Voltage	V_{CES}	80	100	120	Vdc
Emitter-Base Voltage	V_{EBO}	7			Vdc
Collector Current − Continuous	I_C	1			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1 5.71			Watt mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	5 28.6			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

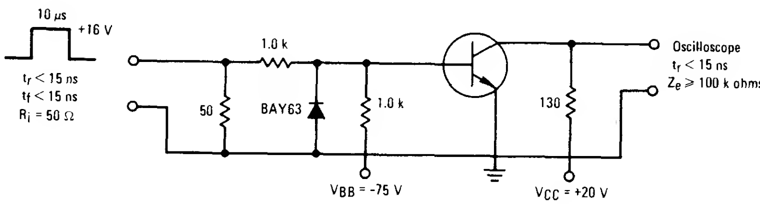
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mAdc, I_B = 0)	BSX45 BSX46 BSX47	$V_{(BR)CEO}$	40 60 80		Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BSX45 BSX46 BSX47	$V_{(BR)CES}$	80 100 120		Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	7		Vdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}		10	nAdc
Collector Cutoff Current (V_{CE} = 60 V, V_{BE} = 0) (V_{CE} = 80 V, V_{BE} = 0) (V_{CE} = 60 V, V_{BE} = 0, T_C = 150°C) (V_{CE} = 80 V, V_{BE} = 0, T_C = 150°C)	BSX45,46 BSX47 BSX45,46 BSX47	I_{CES}		10 10 10 10	nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)(1)	Gr. 6 Gr. 10 Gr. 16 Gr. 6 Gr. 10 Gr. 16 Gr. 6 Gr. 10 Gr. 16	h_{FE}	10 15 25 40 63 100 15 25 35	 100 160 250	
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1 A, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	0.75	1 1.5 2	Vdc
Collector-Emitter Saturation Voltage (I_C = 1 Adc, I_B = 100 mAdc)		$V_{EC(sat)}$		1	Vdc
SMALL SIGNAL CHARACTERISTICS					
Transition Frequency (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50		MHz
Emitter-Base Capacitance (V_{BE} = 0.5 V, f = 1 MHz)		C_{ib}		80	pF

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Capacitance (V_{CB} = 10 V, f = 1 MHz)	BSX45 BSX46 BSX47	C_{ob}		25 20 15	pF
Turn On Time	See Figure 1 (I_C = 100 mAdc)	t_{on}		200	ns
Turn Off Time	I_{B1} = $-I_{B2}$ = 5 mAdc)	t_{off}		850	

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



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BSX59
BSX60

CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

4

Refer to 2N3725 for graphs.

MAXIMUM RATINGS

Rating	Symbol	BSX 59	BSX 60	Unit
Collector-Emitter Voltage	V_{CEO}	45	30	Vdc
Collector-Emitter Voltage	V_{CES}	60	60	Vdc
Collector-Base Voltage	V_{CBO}	70	70	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current − Continuous	I_C	1		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.5 20		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

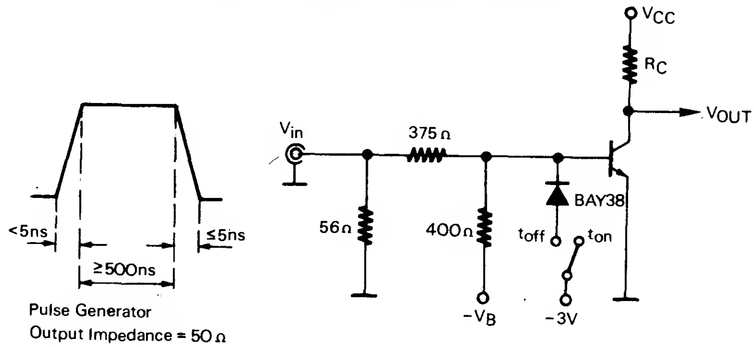
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	[BSX59] [BSX60]	$V_{(BR)CEO}$	45 30		V
Collector-Base Breakdown Voltage ($I_C = 10$ μA, $I_E = 0$)		$V_{(BR)CBO}$	70		V
Collector Cutoff Current ($V_{CB} = 40$ V, $I_E = 0$) ($V_{CB} = 40$ V, $I_E = 0$, $T_J = 150°C$)		I_{CBO}		500 300	nA μA
Emitter Cutoff Current ($V_{EB} = 4.0$ V, $I_C = 0$) ($V_{EB} = 4.0$ V, $I_E = 0$, $T_J = 150°C$)		I_{EBO}		300 50	nA μA
Collector Cutoff Current ($V_{CE} = 40$ V, $-V_{BE} = 4.0$ V) ($V_{CE} = 40$ V, $-V_{BE} = 4.0$ V, $T_J = 150°C$)		I_{CEX}		500 300	nA μA
Emitter Cutoff Current ($V_{CE} = 40$ V, $-V_{BE} = 4.0$ V) ($V_{CE} = 40$ V, $-V_{BE} = 4.0$ V, $T_J = 150°C$)		I_{BEX}		500 300	nA μA
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA) ($I_C = 500$ mA, $I_B = 50$ mA) ($I_C = 1.0$ A, $I_B = 100$ mA)		$V_{CE(sat)}$		0.3 0.5 1.0	V
Base-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA) ($I_C = 500$ mA, $I_B = 50$ mA) ($I_C = 1.0$ A, $I_B = 100$ mA)	 [BSX59] [BSX60]	$V_{BE(sat)}$		1.0 1.2 1.3 1.8	V
DC Current Gain ($I_C = 150$ mA, $V_{CE} = 1.0$ V) ($I_C = 500$ mA, $V_{CE} = 1.0$ V) ($I_C = 1.0$ A, $V_{CE} = 5.0$ V)	 [BSX59] [BSX60] [BSX59] [BSX60]	h_{FE}	30 25 30 20 25	90	
SMALL SIGNAL CHARACTERISTICS					
Small Signal Current Gain ($I_C = 50$ mA, $V_{CE} = 10$ V, f = 100 MHz)		$\|h_{fe}\|$	2.5		
Input Capacitance ($-V_{BE} = 0.5$ V, $I_C = 0$, f = 1.0 MHz)		C_{ib}		60	pF

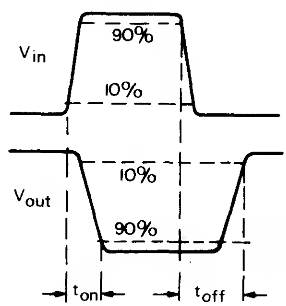
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1.0 MHz)	C_{ob}		10	pF
Turn On Time (See Figure 1) (I_C = 500 mA, I_B = 50 mA, $-V_{BE}$ = 2.0 V)	t_{on}			ns
(V_{CC} = 50 V) [BSX59]			35	
(V_{CC} = 30 V) [BSX60]			40	
Turn Off Time (See Figure 1) (I_C = 500 mA, I_{B1} = I_{B2} = 50 mA)	T_{off}			ns
(V_{CC} = 50 V) [BSX59]			60	
(V_{CC} = 30 V) [BSX60]			70	

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



Measurement		BSX59 BSX61	BSX60	
	V_{CC} / R_C	50 / 100	30 / 60	V / Ω
t_{on}	$-V_B$ / V_{in}	4.0 / 24.75		V / V
t_{off}	$-V_B$ / V_{in}	16.7 / 37.5		V / V



CV8616

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current − Continuous	I_C	100	mAmp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 2.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +175	°C

THERMAL CHARACTERISTICS

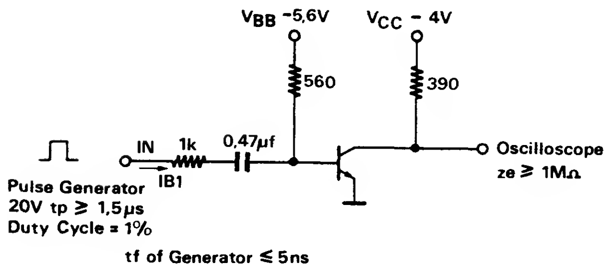
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mA, I_B = 0)	$V_{CEO(sus)}$	20		V
Collector Cutoff Current (V_{CE} = 20 V, I_E = 0) (V_{CE} = 20 V, I_E = 0, T_A = 100°C)	I_{CBO}		50 20	nA μA
Emitter Cutoff Current (V_{EB} = 5.0 V, I_C = 0) (V_{EB} = 1.5 V, I_C = 0) (V_{EB} = 1.5 V, I_C = 0, T_A = 100°C)	I_{EBO}		10 25 20	μA nA μA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage(1) (I_C = 30 mA, I_B = 1.5 mA)	$V_{CE(sat)}$		0.4	V
Base-Emitter Saturation Voltage(1) (I_C = 10 mA, I_B = 1 mA) (I_C = 50 mA, I_B = 2.5 mA)	$V_{BE(sat)}$		0.9 1.6	V
DC Current Gain(1) (I_C = 1 mA, V_{CE} = 0.4 V) (I_C = 10 mA, V_{CE} = 0.4 V) (I_C = 30 mA, V_{CE} = 0.4 V) (I_C = 50 mA, V_{CE} = 0.75 V)	h_{FE}	30 35 20 20		
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 12 V, f = 20 MHz)	f_T	50		MHz
Output Capacitance (V_{CB} = 10 V, f = 1 MHz)	C_{obo}		10	pF
Input Capacitance (V_{EB} = 0.5 V, f = 1 MHz)	C_{ibo}	6	25	pF
Storage Time (See Figure 1) (V_{CC} = 10 V, I_C = 10 mA) (I_{B1} = I_{B2} = 10 mA)	t_s		50	ns

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



4

CV9507

(CECC 50004-050)
CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N2904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current − Continuous	I_C	0.6	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 3.33	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +175	°C

THERMAL CHARACTERISTICS

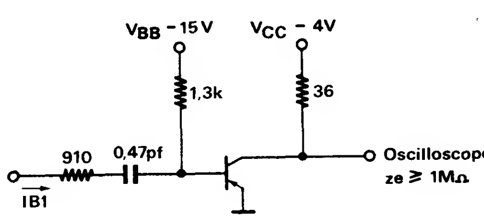
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mA, I_B = 0)	$V_{CEO(sus)}$	65		Vdc
Collector Cutoff Current (V_{CB} = 50 V, I_E = 0) (V_{CB} = 50 V, I_E = 0, T_A = 100°C)	I_{CBO}		75 1	nA µA
Emitter Cutoff Current (V_{EB} = 3 V, I_C = 0) (V_{EB} = 5 V, I_C = 0)	I_{EBO}		100 10	nA µA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage(1) (I_C = 150 mA, I_B = 15 mA)	$V_{CE(sat)}$		0.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mA, I_B = 15 mA) (I_C = 30 mA, I_B = 1 mA)	$V_{BE(sat)}$		1.3 0.9	Vdc
DC Current Gain (I_C = 1 mA, V_{CE} = 0.4 V) (I_C = 10 mA, V_{CE} = 0.4 V) (I_C = 50 mA, V_{CE} = 0.4 V) (I_C = 150 mA, V_{CE} = 0.4 V)	h_{FE}	40 50 20 10	200	
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 20 MHz)	f_T	50		MHz
Output Capacitance (V_{CB} = 10 V, f = 1 MHz)	C_{obo}		12	pF
SWITCHING CHARACTERISTICS				
Storage Time (See Figure 1) (V_{CC} = −4 V, I_C = −100 mA) (I_{B1} = I_{B2} = 10 mA)	t_s		250	ns

(1) Pulsed: Pulse Duration = 300 µs, Duty Cycle = 1%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



CV9543

(CECC 50004-067)
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N3251 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current − Continuous	I_C	100	mAmp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 2.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +175	°C

THERMAL CHARACTERISTICS

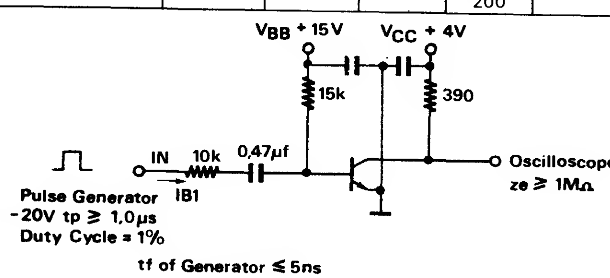
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mA, I_B = 0)	$V_{CEO(sus)}$	20			V
Collector Cutoff Current (V_{CB} = 20 V, I_B = 0) (V_{CB} = 25 V, I_B = 0)	I_{CBO}			50 10	nA µA
Collector Cutoff Current (V_{CE} = 13 V, I_B = 0, T_A = 100°C)	I_{CEO}			45	µA
Emitter Cutoff Current (V_{CB} = 1.5 V, I_C = 0) (V_{CB} = 5 V, I_C = 0) (V_{CB} = 1.5 V, I_C = 0, T_A = 100°C)	I_{EBO}			25 10 15	nA µA µA
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage(1) (I_C = 30 mA, I_B = 1.5 mA)	$V_{CE(sat)}$			0.4	V
Base-Emitter Saturation Voltage(1) (I_C = 10 mA, I_B = 1.0 mA) (I_C = 50 mA, I_B = 2.5 mA)	$V_{BE(sat)}$			0.9 1.6	V
DC Current Gain (I_C = 1 mA, V_{CE} = 0.4 V) (I_C = 10 mA, V_{CE} = 0.4 V) (I_C = 30 mA, V_{CE} = 0.4 V) (I_C = 50 mA, V_{CE} = 0.75 V)	h_{FE}	30 35 20 20			
DYNAMIC CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 12 V, f = 20 MHz)	f_T	100			MHz
Output Capacitance (V_{CB} = 10 V, f = 1 MHz)	C_{ob}			10	pF
Storage Time (See Figure 1) (I_C = 10 mA, I_{B1} = I_{B2} = 1 mA)	t_s			200	ns

(1) Pulsed: Pulse Duration = 300 µs, Duty Cycle = 1%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



CV9790

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current − Continuous	I_C	0.6	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 3.43	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +175	°C

Refer to 2N2904 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0) (1)	$V_{(BR)CEO}$	60		V
Collector Cutoff Current (V_{CB} = 50 V, I_E = 0) (V_{CB} = 50 V, I_E = 0, T_A = 100°C)	I_{CBO}		75 1	nA μA
Emitter-Base Cutoff Current (V_{EB} = 3 V, I_C = 0) (V_{EB} = 5 V, I_C = 0)	I_{EBO}		100 10	nA μA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA) (1)	$V_{CE(sat)}$		0.4	V
Emitter-Base Saturation Voltage (I_C = 30 mA, I_B = 1 mA) (1) (I_C = 150 mA, I_B = 15 mA (1)	$V_{BE(sat)}$		0.9 1.3	V
DC Current Gain (V_{CE} = 10 V, I_C = 10 mA) (1) I_C = 150 mA) (1) I_C = 1 mA) I_C = 50 mA)	h_{FE}	50 40 40 50	200	
SMALL SIGNAL CHARACTERISTICS				
Transition Frequency (V_{CE} = 20 V, I_C = 50 mA, f = 100 MHz)	f_T	100		MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}		12	pF

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

CV10253
CV12253

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current – Continuous	I_C	0.6	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	250	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mA, I_B = 0)		$V_{CEO(sus)}$	65		V
Collector Cutoff Current (V_{CB} = 50 V, I_E = 0)		I_{CBO}		20	nA
Emitter Cutoff Current ($I_{EBO(1)}$ V_{EB} = 3 V, I_C = 0) ($I_{EBO(2)}$ V_{EB} = 5 V, I_C = 0)		I_{EBO}		20 2	nA µA
Collector Cutoff Current (V_{CE} = 50 V, T_A = 100°C)		I_{CEO}		80	µA
ON CHARACTERISTICS					
DC Current Gain ($h_{21e(1)}$ I_C = 1.0 mA, V_{CE} = 0.4 V) ($h_{21e(2)}$ I_C = 10 mA, V_{CE} = 0.4 V) ($h_{21e(3)}$ I_C = 150 mA, V_{CE} = 0.75 V)(1) ($h_{21e(4)}$ I_C = 50 mA, V_{CE} = 0.4 V)		h_{FE}	40 50 25 35	— 200 — —	
Base-Emitter Saturation Voltage(1) (I_C = 30 mA, I_B = 1 mA) (I_C = 150 mA, I_B = 15 mA)		$V_{BE(sat)}$		0.9 1.3	V
SMALL SIGNAL CHARACTERISTICS					
Current Gain Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 35 MHz)		f_T	60		MHz
Storage Time (V_{CC} = 45 V, I_C = 100 mA, I_{B1} = I_{B2} = 10 mA)	CV10253 CV12253	t_s	172	250 550	ns
Output Capacitance (V_{CB} = 10 V, f = 1 MHz)		C_{ob}		20	pF

(1) Pulsed: Pulse Duration = 300 µs, Duty Cycle = 1%.

CV10440

(CECC 50004-087)
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current – Continuous	I_C	250	mAmp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 2.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +175	°C

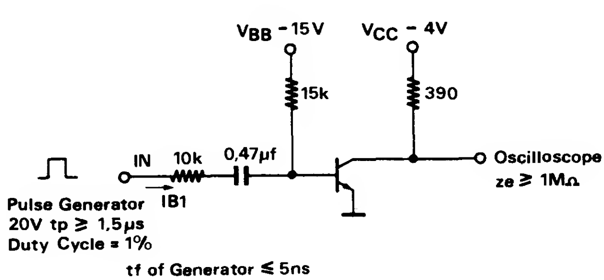
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mA, I_B = 0)	$V_{CEO(sus}$	45		Vdc
Collector Cutoff Current (Emitter Open) (V_{CB} = 30 V, I_B = 0) (V_{CB} = 30 V, I_B = 0, T_A = 100°C)	I_{CBO}		100 15	nA µA
Emitter Cutoff Current (V_{EB} = 5 V, I_C = 0)	I_{EBO}		500	nA
ON CHARACTERISTICS				
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1 mA) (I_C = 50 mA, I_B = 2.5 mA)	$V_{BE(sat)}$		0.9 1.6	Vdc Vdc
DC Current Gain (I_C = 10 µA, V_{CE} = 0.4 V) (I_C = 1 mA, V_{CE} = 0.4 V) (I_C = 10 mA, V_{CE} = 0.4 V)	h_{fe}	40 175 225	 500 550	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1 mA)	$V_{CE(sat)}$		0.3	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 5 V, f = 35 MHz)	f_T	200		MHz
Output Capacitance (V_{CB} = 5 V, I_E = 0, f = 1 MHz)	C_{ob}		B	pF
SWITCHING CHARACTERISTICS				
Storage Time (See Figure 1) (V_{CC} = 4 V, V_{BB} = 15 V, I_C = 10 mA, I_{B1} = I_{B2} = 1 mA)	t_s		750	ns

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



CV10814

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current − Continuous	I_C	100	mAmp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mWatt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	200	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 2 mA, I_B = 0)	$V_{CEO(sus}$	40		V
Collector Cutoff Current (Emitter Open) (V_{CB} = 30 V, I_E = 0) (V_{CB} = 30 V, I_E = 0, T_A = 100°C)	I_{CBO}		100 4	nA μA
Emitter Cutoff Current (Collector Open) (V_{EB} = 5 V, I_C = 0)	I_{EBO}		500	nA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1 mA)	$V_{CE(sat)}$		0.3	V
DC Current Gain (I_C = 10 μA, V_{CE} = 5 V) (I_C = 2 mA, V_{CE} = 5 V)	h_{FE}	40 125	 400	
SMALL SIGNAL CHARACTERISTICS				
Current Gain Bandwidth Product (I_C = 10 mA, V_{CE} = 5 V, f = 100 MHz)	f_T	200		MHz
Small Signal Current Gain (I_C = 1 mA, V_{CE} = 10 V, f = 1 kHz)	h_{fe}	100	400	
Noise Figure (R_g = 2 KΩ, V_{CE} = 5 V, I_E = 200 μA, f = 30 Hz to 15 kHz	NF		2	dB
Output Capacitance (V_{CB} = 5 V, f = 1 MHz)	C_{obo}		8	pF

MM420
MM421

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

TRANSISTOR

NPN SILICON

4

Refer to 2N3439 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MM420	MM421	Unit
Collector-Emitter Voltage	V_{CEO}	250	325	Vdc
Collector-Base Voltage	V_{CBO}	275	350	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Base Current	I_B	100	100	mA
Collector Current — Continuous	I_C	100	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 5.3		mW mW/°C
Total Device Dissipation @ T_A = 75°C Derate above 75°C	P_D	2.5 25		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mA, I_B = 0)	MM420 MM421	$V_{CEO(sus)}$	250 325	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc)	MM420 MM421	$V_{(BR)CBO}$	275 350	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc)		$V_{(BR)EBO}$	6	—	Vdc
Collector Cutoff Current (V_{CE} = 250 Vdc, I_B = 0) (V_{CE} = 325 Vdc, I_B = 0)	MM420 MM421	I_{CEO}	— —	1.0 1.0	mAdc
Collector Cutoff Current (V_{BE} = 275 Vdc, I_E = 0) (V_{BE} = 350 Vdc, I_E = 0)	MM420 MM421	I_{CBO}	— —	100 100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 20 Vdc) (I_C = 10 mAdc, V_{CE} = 20 Vdc) (I_C = 30 mAdc, V_{CE} = 20 Vdc)		h_{FE}	15 25 25	— — 250	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)		$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter On Voltage (I_C = 30 mA, V_{CE} = 20 V)		$V_{BE(on)}$	—	1.0	V
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mA, V_{CE} = 20 V, f = 10 MHz)		f_T	15	—	MHz
Output Capacitance (V_{CB} = 20 V, f = 100 kHz)	(Common Base)	C_{obo}	—	12	pF

(1) PW ≤ 300 μsec, Duty Cycle ≤ 2.0%.

MM3000 thru MM3003

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	MM3000	MM3001	MM3002	MM3003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0				Vdc
Collector Current — Continuous	I_C	200	200	50	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71				Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6				Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200				°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MM3000 MM3001 MM3002 MM3003	$V_{(BR)CEO}$	100 100 150 200 250	— — — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 75$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$)	MM3000 MM3001 MM3002, MM3003	I_{CBO}	— — —	1.0 1.0 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	20	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	150	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 100 kHz)	MM3000, MM3001 MM3002, MM3003	C_{obo}	— —	7.0 15	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM3005
MM3006
MM3007

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AUDIO TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	MM3005	MM3006	MM3007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	80	100	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	2.5			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.0 45.6			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MM3005 MM3006 MM3007	$V_{(BR)CEO}$	60 80 100	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM3005 MM3006 MM3007	$V_{(BR)CBO}$	80 100 120	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0)	MM3005 MM3006 MM3007	I_{CBO}	— — —	100 100 100	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 200 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)	All Types MM3005 MM3006 MM3007	h_{FE}	40 50 50 50	— 250 250 250	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.35	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	0.60	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	15	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM3008
MM3009

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	MM3008	MM3009	Unit
Collector-Emitter Voltage	V_{CEO}	120	180	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	400		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MM3008 MM3009	$V_{(BR)CEO}$	120 180	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 180$ Vdc, $I_E = 0$)	MM3008 MM3009	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}		0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	30 40 30	— — —	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM3726

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

4

Refer to 2N3467 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.5	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	 30 15	 120 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	 — —	 0.6 1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	 0.8 —	 1.1 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz, emitter guarded)	C_{cb}	—	10	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz, collector guarded)	C_{eb}	—	80	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, R_B = 200 ohms, R_L = 60 ohms)	t_{on}	—	30	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc, R_B = 200 ohms, R_L = 60 ohms)	t_{off}	—	90	ns
Turn-On Time (V_{CC} = 30 Vdc, V_{BE} = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc, R_B = 100 ohms, R_L = 30 ohms)	t_{on}	—	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc, R_B = 100 ohms, R_L = 30 ohms)	t_{off}	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM4000 thru MM4003

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3494 for graphs for MM4000.*

MAXIMUM RATINGS

Rating	Symbol	MM4000	MM4001	MM4002	MM4003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.42	1.0 5.71	1.0 5.71	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	5.0 28.6	5.0 28.6	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MM4000 MM4001 MM4002 MM4003	$V_{(BR)CEO}$	100 150 200 250	— — — —	Vdc
Collector-Base Breakdown Voltage (I_E = 0, I_C = 100 μAdc)	MM4000 MM4001 MM4002 MM4003	$V_{(BR)CBO}$	100 150 200 250	— — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 150 Vdc, I_E = 0)	MM4000 MM4001 MM4002, MM4003	I_{CBO}	— — —	1.0 1.0 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	—	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	MM4000, MM4001 MM4002, MM4003	$V_{CE(sat)}$	— —	0.6 5.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	MM4000 MM4001 MM4002, MM4003	C_{obo}	— — —	6.0 10 20	pF

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.
*Refer to 2N3634 for graphs for MM4001.
Refer to 2N3743 for graphs for MM4002 and MM4003.

MAXIMUM RATINGS

Rating	Symbol	MM4005	MM4006	MM4007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	1.0			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MM4005 thru MM4007

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4405 for graphs.

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	MM4005 MM4006 MM4007	$V_{(BR)CEO}$	60 80 100	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM4005 MM4006 MM4007	$V_{(BR)CBO}$	60 80 100	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	MM4005 MM4006 MM4007	I_{CBO}	— — —	— — —	100 100 100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	40 50	90 150	— —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.1	—	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	—	0.7	—	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	10	—	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	100	—	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

MM4036
MM4037

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector-Emitter Voltage	MM4036 MM4037	V_{CEO}	65 40	Vdc
Collector-Base Voltage	MM4036 MM4037	V_{CBO}	90 60	Vdc
Emitter-Base Voltage		V_{EBO}	5.0	Vdc
Base Current		I_B	500	mAdc
Collector Current — Continuous		I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C		P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C		P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	MM4036 MM4037	$V_{(BR)CEO}$	65 40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$) ($I_C = 10\ \mu$Adc, $I_E = 0$)	MM4036 MM4037	$V_{(BR)CBO}$	90 60	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$) ($I_E = 1.0\ \mu$Adc, $I_C = 0$)	MM4036 MM4037	$V_{(BR)EBO}$	5.0 5.0	— —	— —	Vdc
Collector Cutoff Current(1) ($V_{CE} = 60$ Vdc, $V_{BE(off)} = 1.5$ Vdc) ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 1.5$ Vdc, $T_C = 150°C$)	MM4036 MM4036	I_{CEV}	— —	— —	250 100	nAdc μAdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$)	MM4036, MM4037	I_{CBO}	—	—	250	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$) ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	MM4036 MM4037	I_{EBO}	— —	— —	250 1.0	μAdc
ON CHARACTERISTICS(2)						
DC Current Gain ($I_C = 100\ \mu$Adc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 2.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	MM4036 MM4036 MM4036 MM4036 MM4037 MM4037	h_{FE}	20 20 40 20 15 50	50 60 90 40 50 75	— 200 140 — — 250	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	MM4036 MM4037	$V_{CE(sat)}$	—	0.3 0.3	0.65 1.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{BE(sat)}$	—	1.0	1.4	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	60	100	—	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MM4036, MM4037	C_{ibo}	—	60	—	pF
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MM4036	C_{cb}	—	20	—	pF
	MM4037		—	20	30	
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	—	40	75	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	110	175	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

MM5005
MM5006
MM5007

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AUDIO TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	MM5005	MM5006	MM5007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	80	100	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	2.0			Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.5 8.57			Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	8.0 45.7			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MM5005 MM5006 MM5007	$V_{(BR)CEO}$	60 80 100	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MM5005 MM5006 MM5007	$V_{(BR)CBO}$	80 100 120	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$)	MM5005 MM5006 MM5007	I_{CBO}	— — —	200 200 200	nAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 2.5$ Vdc) ($I_C = 200$ mAdc, $V_{CE} = 2.5$ Vdc) ($I_C = 250$ mAdc, $V_{CE} = 2.5$ Vdc)	All Types MM5005 MM5006 MM5007	h_{FE}	40 50 50 50	— 250 250 250	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 150$ mAdc, $V_{CE} = 2.5$ Vdc)		$V_{BE(on)}$	0.65	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		f_T	30	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM5415
MM5416

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	MM5415	MM5416	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	Vdc
Collector-Base Voltage	V_{CBO}	200	350	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	7.0	Vdc
Base Current	I_B	0.5		Adc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 6.7		Watt W/°C
Total Power Dissipation @ T_C = 50°C Linear Derating Factor	P_D	10 0.057		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	150	°C/W

Refer to 2N5415 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mA, I_B = 0)	MM5415 MM5416	$V_{CEO(sus)}$	200 300	— —	Vdc
Collector Cutoff Current (V_{CE} = 150 Vdc, I_B = 0)	MM5415, MM5416	I_{CEO}	—	50	μAdc
Collector Cutoff Current (V_{CE} = 175 Vdc, I_E = 0) (V_{CE} = 280 Vdc, I_E = 0)	MM5415 MM5416	I_{CBO}	— —	50 50	μAdc μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0) (V_{BE} = 7.0 Vdc, I_C = 0)	MM5415 MM5416	I_{EBO}	— —	20 20	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	MM5415 MM5416	h_{FE}	30 30	150 120	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	MM5415, MM5416	$V_{CE(sat)}$	—	2.5	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 V)	MM5415, MM5416	$V_{BE(on)}$	—	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)		f_T	15	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{obo}	—	25	pF
Current Gain — High Frequency (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		$\|h_{fe}\|$	25	—	—
Real Part of Input Impedance (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		$Re(h_{ie})$	—	300	Ohms

MM6427

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

DARLINGTON TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	300	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	375 2.14	mW W/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.25 7.15	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	140	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	467	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 5000 10,000	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	15	pF
Small-Signal Current Gain(1) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	h_{fe}	1.25	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

P038

(CECC 50002-169)
CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current – Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mA, I_B = 0)	$V_{CEO(sus)}$	300		V
Collector Cutoff Current (V_{CB} = 300 V, I_E = 0) (V_{CB} = 240 V, I_E = 0) (V_{CB} = 240 V, I_E = 0)	I_{CBO}		 50 10 100	 μA μA nA
Collector Cutoff Current (V_{CE} = 240 V, I_B = 0)	I_{CEO}		500	nA
Emitter Cutoff Current (V_{EB} = 3 V, I_C = 0)	I_{EBO}		100	nA
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage (I_C = 1 mA, I_B = 40 μA)	$V_{CE(sat)}$		0.5	V
Base-Emitter Saturation Voltage (I_C = 1 mA, I_B = 10 μA)	$V_{BE(sat)}$		0.8	V
Common Emitter Static Value of the Forward Current Transfer Ratio ($h_{21E}(1)$ I_C = 20 μA, V_{CE} = 0.5 V) ($h_{21E}(2)$ I_C = 200 μA, V_{CE} = 0.5 V)	h_{FE}	 25 25	 200 200	
SMALL SIGNAL CHARACTERISTICS				
Transition Frequency (I_C = 15 mA, V_{CB} = 10 V)	f_T	35		MHz
Collector-Base Capacitance (V_{CB} = 5 V, f = 1 MHz)	C_{obo}		25	pF

(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.

4

P039

(CECC 50002-170)
CASE 79, STYLE 1
TO-39 (TO-205AD)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to 2N3439 for graphs.

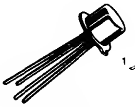
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current – Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Total Device Dissipation T_A = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	°C

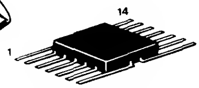
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mA, I_B = 0)	$V_{CEO(sus)}$	300		V
Collector-Emitter Cutoff Current (V_{CE} = 240 V)	I_{CEO}		10	μA
Collector-Base Cutoff Current (V_{CB} = 240 V) (V_{CB} = 240 V, T_{Amb} = 100°C)	I_{CBO}		500 5	nA μA
Emitter-Base Cutoff Current (V_{EB} = 3 V)	I_{EBO}		1	μA
ON CHARACTERISTICS				
Static Forward Current Transfer(1) (I_C = 100 mA, V_{CE} = 1 V) (I_C = 1.0 mA, V_{CE} = 1 V) (I_C = 25 mA, V_{CE} = 1 V)	h_{FE}	25 30 30	150 200	
Collector-Emitter Saturation Voltage(1) (I_C = 200 mA, I_B = 20 mA) (I_C = 25 mA, I_B = 1.25 mA)	$V_{CE(sat)}$		3.0 0.2	V
Base-Emitter Saturation Voltage(1) (I_C = 25 mA, I_B = 1.25 mA)	$V_{BE(sat)}$		0.9	V
SMALL SIGNAL CHARACTERISTICS				
Transition Frequency (I_C = 50 mA, V_{CB} = 10 V, f = 5 MHz)	f_T	10		MHz
Output Capacitance (V_{CB} = 10 V, f = 1 mHz)	C_{obo}		25	pF

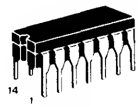
(1) Pulsed: Pulse Duration = 300 μs, Duty Cycle = 1%.



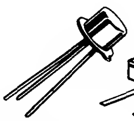
CASE 20-03
TO-72



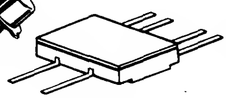
CASE 607-04



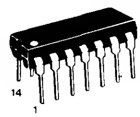
CASE 632



CASE 22-03
TO-18



CASE 610A-04



CASE 646

Motorola's multiple (Duals and Quads) transistors have been implemented with discrete transistor chips that have proven to be the most popular for all-around performance at low cost.

Packaging options include plastic and ceramic DIP's, ceramic flat pak, and various metal-can outlines.

Multiple Transistors

5

2N998

CASE 20-03, STYLE 8
TO72 (TO206AF)

DARLINGTON TRANSISTOR

NPN SILICON

5

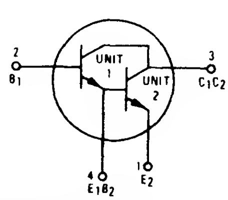
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	15	Vdc
Collector Current − Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.86	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1)	I_C = 30 mAdc, I_B = 0	$V_{CEO(sus)}$	60		Vdc
Collector-Base Breakdown Voltage	I_C = 100 μAdc, I_E = 0	$V_{(BR)CBO}$	100		Vdc
Emitter-Base Breakdown Voltage	I_E = 100 μAdc, I_C = 0	$V_{(BR)EBO}$	15		Vdc
Collector Cutoff Current	V_{CB} = 90 V, I_E = 0 V_{CB} = 90 V, I_E = 0, T_A = 150°C	I_{CBO}		0.01 15	μAdc
Emitter Cutoff Current	V_{BE} = 10 V, I_C = 0	I_{EBO}		0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain	(I_C = 1 mAdc, V_{CE} = 5 Vdc) (I_C = 10 mAdc, V_{CE} = 5 Vdc) (I_C = 100 mAdc, V_{CE} = 5 Vdc) (I_C = 10 mAdc, V_{CE} = 5 Vdc) (2)	h_{FE}	800 1600 2000 25	 8000 	
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain	(I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	h_{fe}	1000		—
Output Capacitance	(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}		30	pF
Input Capacitance	(V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}		50	pF
Noise Figure	(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 5 kohms, f = 1 kHz, Δf = 200 Hz)	NF		6	dB

(1) Pulse Test: Pulse Width < 300 μs, Duty Cycle ≤ 2%
(2) Measured across each transistor within the device



The input unit is identified as Unit 1 regardless of terminal numbering.

MAXIMUM RATINGS

Rating	Symbol	2N2060,A 2N2223,A	2N2480	2N2480A	Unit
Collector-Emitter Voltage	V_{CEO}	60	40	40	Vdc
Collector-Emitter Voltage	V_{CER}	80	—	—	Vdc
Collector-Base Voltage	V_{CBO}	100	75	80	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	5.0	5.0	Vdc
Collector Current — Continuous	I_C	500			mAdc

		One Die	All Die Equal Power	Unit
Total Device Dissipation @ T_A = 25°C	P_D			mW
2N2060,A		0.5	0.6	
2N2223,A		0.5	0.6	
2N2480,A		0.3	0.6	
Derate above 25°C				mW/°C
2N2060,A		2.86	3.43	
2N2223,A		2.86	3.43	
2N2480,A		1.72	3.43	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
2N2060,A		1.5	3.0	
2N2223,A		1.6	3.0	
2N2480,A		1.0	2.0	
Derate above 25°C				mW/°C
2N2060,A		8.6	17.2	
2N2223,A		9.1	11.4	
2N2480,A		5.7	11.4	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

2N2060,A
2N2223,A
2N2480,A

2N2060 JAN, JTX, JTXV AVAILABLE
CASE 654-07, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD2218 for graphs.

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, R_{BE} ≤ 10 ohms)	2N2060, 2N2060A, 2N2223, 2N2223A	$V_{CER(sus)}$	80	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 20 mAdc, I_B = 0)	2N2480	$V_{CEO(sus)}$	40	—	Vdc
	2N2480A		40	—	
(I_C = 30 mAdc, I_B = 0)	2N2060, 2N2060A, 2N2223, 2N2223A		60	—	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N2060, 2N2060A, 2N2223, 2N2223A	$V_{(BR)CBO}$	100	—	Vdc
	2N2480*		75	—	
	2N2480A*		80	—	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, i_C = 0)	2N2060, 2N2060A, 2N2223, 2N2223A	$V_{(BR)EBO}$	7.0	—	Vdc
	2N2480, 2N2480A		5.0	—	
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N2480, 2N2480A	I_{CBO}	—	15	μAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N2480		—	0.050	
	2N2480A		—	0.020	
(V_{CB} = 80 Vdc, I_E = 0)	2N2060, 2N2060A		—	0.002	
	2N2223, 2N2223A		—	0.010	
(V_{CB} = 80 Vdc, I_E = 0, T_A = 150°C)	2N2060, 2N2060A		—	10	
	2N2223, 2N2223A		—	15	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N2060, 2N2060A	I_{EBO}	—	2.0	nAdc
	2N2223, 2N2223A		—	10	
	2N2480		—	50	
	2N2480A		—	20	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A 2N2223, 2N2223A	h_{FE}	25 15	75 —	—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A 2N2223, 2N2223A 2N2480 2N2480A		30 25 20 35	90 150 — —	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A 2N2480 2N2480A		40 30 50	120 350 200	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A 2N2223, 2N2223A		50 50	150 200	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	2N2060A 2N2060, 2N2223, 2N2223A, 2N2480A 2N2480	$V_{CE(sat)}$	— — —	0.6 1.2 1.3	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A 2N2480	$V_{BE(sat)}$	— —	0.9 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N2223, 2N2223A 2N2480, 2N2480A 2N2060, 2N2060A	f_T	50 60	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N2060, 2N2060A, 2N2223, 2N2223A 2N2480A 2N2480	C_{obo}	— — —	15 18 20	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A	C_{ibo}	—	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A 2N2480A	h_{ie}	1000 1000	4000 5000	ohms
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A, 2N2223, 2N2223A 2N2480A	h_{ib}	20 20	30 35	ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2223, 2N2223A	h_{rb}	—	3.0	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A 2N2223, 2N2223A 2N2480A	h_{fe}	50 40 50	150 200 300	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A, 2N2480A	h_{oe}	—	16	μmhos
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2223, 2N2223A	h_{ob}	—	0.5	μmhos
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 Ω, f = 1.0 kHz, BW = 1.0 Hz) (I_C = 0.3 mAdc, V_{CE} = 10 Vdc,	2N2480, 2N2480A	NF	—	8.0	dB

5

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
R_S = 510 Ω, f = 1.0 kHz, BW = 200 Hz) (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz, BW = 15.7 kHz)(2)	2N2060, 2N2060A		— —	8.0 8.0	
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(3) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A, 2N2223A 2N2223, 2N2480, 2N2480A	h_{FE1}/h_{FE2}	0.9 0.8	1.0 1.0	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A 2N2480, 2N2480		0.9 0.8	1.0 1.0	
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060A 2N2060, 2N2223A, 2N2480A 2N2480 2N2223	$\lvert V_{BE1}-V_{BE2}\rvert$	— — — —	3.0 5.0 10 15	mVdc
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A, 2N2480A 2N2480		— —	5.0 10	
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +125°C)	2N2060A 2N2060 2N2223, 2N2223A 2N2480, 2N2480A	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T}$	— — — —	5.0 10 25 15	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Amplifier: 3.0 Db points at 25 Hz and 10 kHz with a roll-off of 6.9 dB per octave.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

FIGURE 1 — DC CURRENT GAIN versus COLLECTOR CURRENT

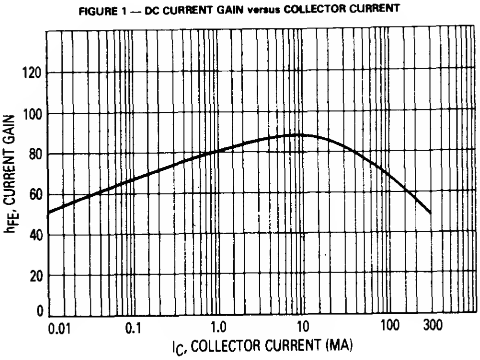
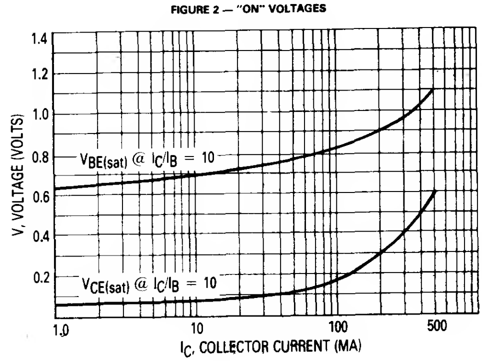


FIGURE 2 — "ON" VOLTAGES



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2N2453,A

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

Refer to 2N2920 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N2453	2N2453A	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	300 1.71	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	600 3.43	1200 6.86	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N2453 2N2453A	$V_{CEO(sus)}$	 30 50	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N2453 2N2453A	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 μAdc, I_C = 0)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	 — —	 0.005 10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	0.002	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)		h_{FE}	 80 40 150 75	 — — 600 —	—
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)		f_T	60	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{ie}	5.0	—	kohms
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	20	30	Ohms

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	—	6.0	X 10^{-4}
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	—	5.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	150	600	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	5.0	30	μmhos
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	—	0.2	μmho
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz)	NF	—	7.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) 2N2453A (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +125°C)	h_{FE1}/h_{FE2}	0.90 0.90 0.85	1.0 1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$\|V_{BE1}-V_{BE2}\|$	— —	3.0 5.0	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +125°C) 2N2453 2N2453A	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	— —	10 5.0	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

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2N2639 thru 2N2644

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

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Refer to 2N2913 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.72	600 3.43	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	600 3.43	1200 6.87	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{CEO(sus)}$	45	—	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)		I_{CEO}	—	0.010	μAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0) (V_{CB} = 45 Vdc, I_E = 0, T_A = +150°C)		I_{CBO}	— —	0.010 10	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644	h_{FE}	50 100	300 300	—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644		10 20	— —	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644		55 110	— —	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644		65 130	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{BE(sat)}$	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	40	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz, I_E = −1.0 mA)		h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz, I_E = −1.0 mA)		h_{rb}	—	600	X 10^{-6}

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644	h_{fe}	65 130	600 600	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz, I_E = −1.0 mA)		h_{ob}	—	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CB} = 5.0 Vdc, R_S = 10 kΩ, Bandwidth = 10 Hz to 15 kHz)		NF	—	4.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2639, 2N2642 2N2640, 2N2643	h_{FE1}/h_{FE2}	0.9 0.8	1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2639, 2N2642 2N2640, 2N2643	$\lvert V_{BE1}-V_{BE2}\rvert$	— —	5.0 10	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +125°C)	2N2639, 2N2642 2N2640, 2N2643	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	— —	10 20	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this test.

2N2652,A

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2060,A for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CBO}	100		Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.72	0.6 3.43	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 5.7	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	100	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.010 15	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0) 2N2652	I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)	h_{FE}	35 50 15	— 200 —	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	15	pF
Input Capacitance (V_{BE} = 0, 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	1.0	10.5	kohms
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	20	35	ohms
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	50	300	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	—	50	μmhos
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 610 ohms, B. W. = 1.0 Hz, f = 1.0 kHz)	NF	—	8.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) 2N2652 (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) 2N2652	h_{FE1}/h_{FE2}	0.85 0.85	1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$\|V_{BE1}-V_{BE2}\|$	— —	3.0 3.0	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +125°C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	10	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2720
2N2721

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2060 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CBO}	80		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	40		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.3 1.71	0.6 3.4	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.6 3.4	1.2 6.8	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	60	—	Vdc
Collector Cutoff Current ($V_{CE} = 5.0$ Vdc, $I_B = 0$)	I_{CEO}	—	10	nAdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	0.01 10	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	30 35 42	120 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	80	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Impedance ($I_E = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)	h_{ib}	25	32	ohms
Voltage Feedback Ratio ($I_E = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)	h_{rb}	—	500	$X 10^{-6}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{fe}	30	200	—
Output Admittance ($I_E = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)	h_{ob}	—	1.0	μmhos
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc) 2N2720 2N2721	h_{FE1}/h_{FE2}	0.9 0.8	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc) 2N2720 2N2721	$\lvert V_{BE1}-V_{BE2}\rvert$	— —	5.0 10	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55$ to $+25°C$) 2N2720 2N2721 ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = +25$ to $+125°C$) 2N2720 2N2721	$\Delta(V_{BE1}-V_{BE2})$	— — — —	0.8 1.6 1.0 2.0	mV

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2722

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

Refer to 2N2920 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	40		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.3 1.7	0.6 3.4	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.6 3.4	1.2 6.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	45	—	Vdc
Collector Cutoff Current ($V_{CE} = 5.0$ Vdc, $I_B = 0$)	I_{CEO}	—	2.0	nAdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	0.001 1.0	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	1.0	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	50 100 125	250 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	100	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Impedance ($I_E = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)	h_{ib}	25	32	ohms
Voltage Feedback Ratio ($I_E = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)	h_{rb}	—	600	$X\ 10^{-6}$
Small-Signal Current Gain ($I_E = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{fe}	100	700	—
Output Admittance ($I_E = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)	h_{ob}	—	1.0	μmhos
Noise Figure ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 10 Hz to 15.7 kHz)	NF	—	4.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) ($I_C = 1.0$ μAdc, $V_{CE} = 5.0$ Vdc)	h_{FE1}/h_{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc)	$\|V_{BE1}-V_{BE2}\|$	—	5.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55$ to $+25°C$) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = +25$ to $+125°C$)	$\Delta(V_{BE1}-V_{BE2})$	— —	0.8 1.0	mVdc

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2723

CASE 20-03, STYLE 8
TO-72 (TO-206AF)

DARLINGTON TRANSISTOR

NPN SILICON

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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CE2O}	60	Vdc
Collector-Base Voltage	V_{CB1}	80	Vdc
Emitter-Base Voltage	V_{E2B1}	12	Vdc
Collector Current — Continuous	I_C	40	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.9	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_{B1} = 0$)	$V_{(BR)CE2O}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_{E2} = 0$)	$V_{(BR)CB1O}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_{E2} = 10$ μAdc, $I_C = 0$)	$V_{(BR)E2B1O}$	12	—	Vdc
Collector Cutoff Current ($V_{CB1} = 60$ Vdc, $I_E = 0$) ($V_{CB1} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CB1O}	 — —	 0.01 10	μAdc
Emitter Cutoff Current ($V_{B1E2} = 10$ Vdc, $I_C = 0$)	I_{E2B1O}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE2} = 5.0$ Vdc, $I_{B2} = 0$)	h_{FE}	2000	10,000	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_{B1} = 1.0$ mAdc)	$V_{CE2(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_{B1} = 1.0$ mAdc)	$V_{BE2(sat)}$	—	1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB1} = 10$ Vdc, $I_{E2} = 0$, f = 140 kHz)	C_{ob1o}	—	10	pF
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE2} = 5.0$ Vdc, f = 1.0 kHz)	h_{fe}	1500	15,000	—
Current Gain — Bandwidth Product (Each Unit) ($I_C = 10$ mAdc, V_{CE1} or $V_{CE2} = 10$ Vdc, f = 20 MHz)	$\|h_{fe}\|$	5.0	—	—
Noise Figure (Input Stage Only) ($I_C = 50$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 3.0$ kohms, f = 1.0 kHz, BW = 100 Hz)	NF	—	10	dB

(1) Pulse Test: Pulse Width ≤ 12 ms, Duty Cycle ≤ 2.0%.

2N2785

CASE 20-03, STYLE 8
TO-72 (TO-206AF)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CE2O}	40	Vdc
Collector-Base Voltage	V_{CB1O}	60	Vdc
Emitter-Base Voltage (Pin 4 to Pin 2)	V_{E2B1O}	15 7.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.9	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 20$ mAdc, $I_{B1} = 0$)	$V_{(BR)CEO2O}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_{E2} = 0$)	$V_{(BR)CBO1O}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_{E2} = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)E2BO1O}$	15	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $I_B = 0$)	I_{CEO}	—	500	nAdc
Collector Cutoff Current ($V_{CB1} = 30$ Vdc, $I_E = 0$) ($V_{CB1} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 0.05 10	μAdc
Emitter Cutoff Current ($V_{E2B1} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 1.0$ mAdc, $V_{CE2} = 4.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE2} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE2} = 5.0$ Vdc)	h_{FE}	 600 1200 2000	 — — 20,000	—
Collector-Emitter Saturation Voltage ($I_C = 15$ mAdc, $I_{B1} = 3.0$ mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB1} = 10$ Vdc, $I_{E2} = 0$, f = 1.0 MHz)	C_{ob1o}	—	30	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB1} = 5.0$ Vdc, f = 1.0 kHz)	h_{ib}	30	80	Ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE2} = 5.0$ Vdc, f = 1.0 kHz)	h_{rb}	—	10	$X\ 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE2} = 5.0$ Vdc, f = 1.0 kHz)	h_{fe}	600	—	—
Current Gain — High Frequency ($I_C = 1.0$ mAdc, $V_{CE2} = 5.0$ Vdc, f = 10 MHz)	$\|h_{fe}\|$	1.0	—	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CB1} = 5.0$ Vdc, f = 1.0 kHz)	h_{ob}	—	0.5	μmhos

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2903,A

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2920 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	300 1.71	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.6 3.43	1.2 6.86	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{CEO(sus)}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)		I_{CBO}	— —	0.01 15	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$)		h_{FE}	60 25 125 60	— — 625 —	—
Collector-Emitter Saturation Voltage ($I_C = 5.0$ mAdc, $I_B = 0.5$ mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 5.0$ mAdc, $I_B = 0.5$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 30 MHz)		f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)		C_{obo}	—	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)		C_{ibo}	—	10	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)		h_{ie}	1.0	—	kohm
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)		h_{ib}	20	30	ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)		h_{re}	—	6.0	X 10^{-4}
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)		h_{rb}	—	5.0	X 10^{-4}
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)		h_{fe}	150	600	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)		h_{oe}	5.0	30	μmhos
Output Admittance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)		h_{ob}	—	0.2	μmho
Noise Figure ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kohms, f = 1.0 kHz)		NF	—	7.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N2903 2N2903A	h_{FE1}/h_{FE2}	0.8 0.9	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc)	2N2903 2N2903A	$\lvert V_{BE1} - V_{BE2}\rvert$	—	10 5.0	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$ to $+125°C$)	2N2903 2N2903A	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	20 10	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

2N2913 thru 2N2920

JAN, JTX, JTXV, JANS AVAILABLE
CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	2N2913 thru 2N2918	2N2919 2N2920	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CBO}	45	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	500 2.86	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	750 4.3	1500 8.6	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	2N2913 thru 18, 2N2919, 2N2920	$V_{(BR)CEO(sus)}$	45 60	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N2913 thru 18, 2N2919, 2N2920	$V_{(BR)CBO}$	45 60	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)		I_{CEO}	—	—	0.002	μAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	2N2913 thru 18, 2N2919, 2N2920	I_{CBO}	— —	— —	0.010 0.002	μAdc
(V_{CB} = 45 Vdc, I_E = 0, T_A = 150°C)	All Types		—	—	10	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	—	0.002	μAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2913,15,17,19, 2N2914,16,18,20	h_{FE}	60 150	— —	240 600	—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)	2N2913,15,17,19, 2N2914,16,18, 2N2920		15 30 40	— — —	— — —	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2913,15,17,19, 2N2914,16,18,20		100 225	— —	— —	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2913,15,17,19, 2N2914,16,18,20		150 300	— —	— —	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	—	0.35	Vdc
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	—	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	60	—	—	MHz

2N2913 thru 2N2920

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	4.0	6.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	28	32	ohms
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	—	—	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz, BW = 200 Hz)	2N2914,16,18,20, 2N2913,15,17,19	NF	— —	2.0 3.0	3.0 4.0	dB
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 kHz, BW = 10 kHz)	2N2914,16,18,20, 2N2913,15,17,19		— —	2.0 3.0	3.0 4.0	
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(2) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2917,18, 2N2915,16,19,20	h_{FE1}/h_{FE2}	0.8 0.9	— —	1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 10 μAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2917,18, 2N2915,16,19,20	$\|V_{BE1}-V_{BE2}\|$	— —	— —	10 5.0	mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2917,18, 2N2915,16,19,20		— —	— —	5.0 3.0	
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +25°C)	2N2917,18, 2N2915,16,19,20	$\Delta(V_{BE1}-V_{BE2})$	— —	— —	1.6 0.8	mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25°C to +125°C)	2N2917,18 2N2915,16,19,20		— —	— —	2.0 1.0	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

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FIGURE 1 — DC CURRENT GAIN versus COLLECTOR CURRENT

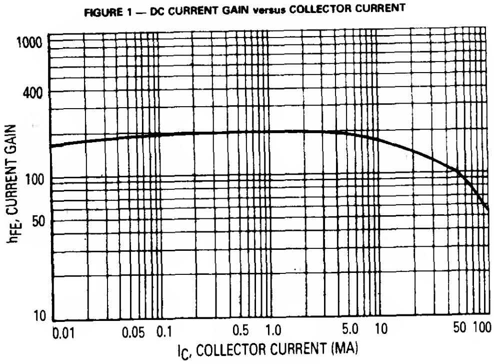


FIGURE 2 — DC CURRENT GAIN versus COLLECTOR CURRENT

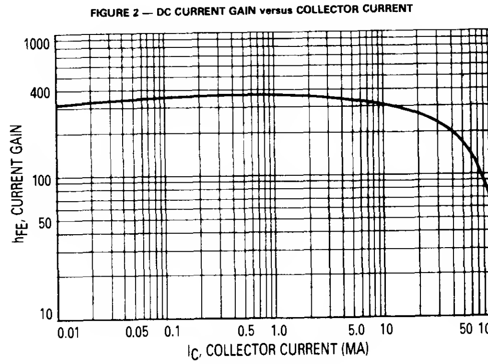


FIGURE 3 — "ON" VOLTAGES

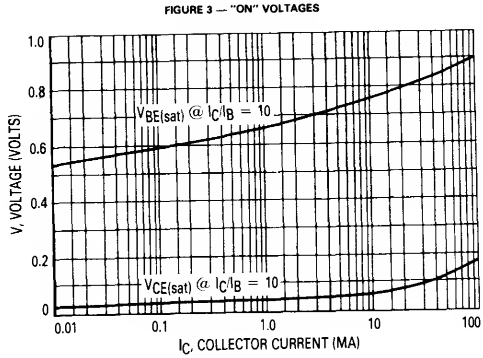
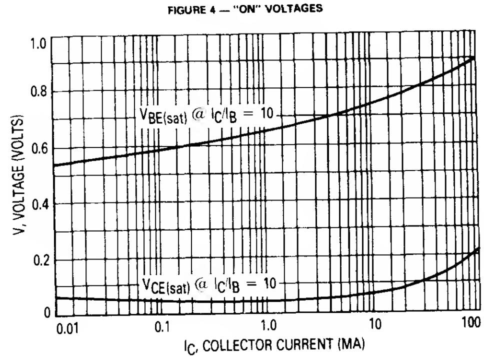


FIGURE 4 — "ON" VOLTAGES



2N3043 thru 2N3048

CASE 610A-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

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MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 1.67	350 2.33	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.7 4.67	1.4 9.33	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0) (V_{CB} = 45 Vdc, I_E = 0, T_A = +150°C)		I_{CBO}	 — —	 0.010 10	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	 2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048	h_{FE}	 100 50	 300 200	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048		130 65	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		V_{BE}	0.6	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	30	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	 2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048	h_{ie}	 3.2k 1.6k	 19k 13k	Ohms
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	 2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048	h_{fe}	 130 65	 600 400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{oe}	 — —	 100 70	μmhos
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, Bandwidth = 10 Hz to 15.7 kHz)		NF	—	5.0	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N3043, 2N3046	h_{FE1}/h_{FE2}	0.9	1.0	—
	2N3044, 2N3047		0.8	1.0	
Base-Emitter Voltage Differential (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N3043, 2N3046	$\lvert V_{BE1}-V_{BE2}\rvert$	—	5.0	mVdc
	2N3044, 2N3047		—	10	
Base-Emitter Voltage Differential Temperature Gradient (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +125°C)	2N3043, 2N3046	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	10	μV/°C
	2N3044, 2N3047		—	20	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this test.

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2N3425

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTORS

NPN SILICON

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Refer to MD2369,A,B for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Emitter Voltage	V_{CER}	20		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.72	0.4 2.28	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.75 4.3	1.5 8.55	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mAdc, R_{BE} ≤ 10 ohms)	$V_{CER(sus)}$	20	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 125°C)	I_{CEX}	—	15	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 VDc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.025 15	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	0.2	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)	h_{FE}	12 30 12	— 120 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = −55°C to +125°C)	$V_{CE(sat)}$	 — —	 0.4 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = −55°C)	$V_{BE(sat)}$	0.7 —	0.85 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	9.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 kHz)	h_{fe}	20	—	—
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 300 MHz)	$Re(h_{ie})$	—	50	Ohms
SWITCHING CHARACTERISTICS				
Storage Time (I_C = 10 mAdc, I_{B1} = 10 mAdc, I_{B2} = 10 mAdc)	t_s	—	40	ns
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{EB(off)}$ = 2.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	50	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{off}	—	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Base Current	I_B	100		mAdc
Collector Current — Continuous	I_C	300		mAdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.29	500 2.86	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.85 4.85	1.4 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Collector1 to Collector2 Voltage Voltage rating any lead to case	V_{C1} V_{C2}	±200 ±200		Vdc Vdc

2N3726
2N3727

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

Refer to MD2905,A for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	$V_{(BR)CBO}$	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.01 mAdc, V_{CE} = 5.0 Vdc) (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)(1)	h_{FE}	 80 120 135 115	 — — 350 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 20 MHz) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	 60 200	 — 600	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	—	11.5	kohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	—	1500	X 10^{-6}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	135	420	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	—	80	μmhos
Noise Figure (I_C = 30 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 1.0 kHz, B.W. = 200 Hz)		NF	—	4.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(3) (I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc)		h_{FE1}/h_{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential (I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N3726	$\|V_{BE1}-V_{BE2}\|$	—	5.0	mVdc
	2N3727		—	2.5	
Base-Emitter Differential Change Due to Temperature (I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +25°C)	2N3726	$\Delta(V_{BE1}-V_{BE2})$	—	1.6	mVdc
	2N3727		—	0.8	
(I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = +25°C to +125°C)	2N3726		—	2.0	
	2N3727		—	1.0	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(3) For purposes of this ratio, the lowest h_{FE} reading is taken as h_{FE1}.

2N3806 thru 2N3810,A 2N3811,A

CASE 610A-04, STYLE 1

2N3812 thru 2N3816,A 2N3817,A

CASE 654-07, STYLE 1

2N3810, 2N3811 — JAN, JTX, JTXV AVAILABLE

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Metal Can (2N3806 thru 2N3810,A, 2N3811,A)	P_D	500	600	mW
Derate above 25°C		2.86	3.43	mW/°C
Total Device Dissipation @ $T_C = 25°C$ Flat Package (2N3812 thru 2N3816,A, 2N3817,A)	P_D	250	350	mW
Derate above 25°C		1.5	2.06	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
($V_{CB} = 50$ Vdc, $I_E = 0$)	2N3816,17,12,13,14,15		—	0.01	
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)			—	10	
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
($I_C = 1.0$ μAdc, $V_{CE} = 5.0$ Vdc)	2N3807,9,11,A,13,15,17,A		75	—	
($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc)	2N3806,8,10,A,12,14,16,A		100	—	
	2N3807,9,11,A,13,15,17,A		225	—	
($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	2N3806,8,10,A,12,14,16,A		150	450	
	2N3807,9,11,A,13,15,17,A		300	900	
($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$)	2N3806,8,10,A,12,14,16,A		75	—	
	2N3807,9,11,A,13,15,17,A		150	—	
($I_C = 500$ μAdc, $V_{CE} = 5.0$ Vdc)	2N3806,8,10,A,12,14,16,A		150	450	
	2N3807,9,11,A,13,15,17,A		300	900	
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N3806,8,10,A,12,14,16,A		150	450	
	2N3807,9,11,A,13,15,17,A		300	900	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	2N3806,8,10,A,12,14,16,A		125	—	
	2N3807,9,11,A,13,15,17,A		250	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
($I_C = 100$ μAdc, $I_B = 1.0$ μA)	2N3814, 2N3815		—	0.2	
($I_C = 1.0$ mAdc, $I_B = 100$ μAdc)			—	0.25	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
($I_C = 100$ μAdc, $I_B = 10$ μAdc)			—	0.7	
($I_C = 1.0$ mAdc, $I_B = 100$ μAdc)			—	0.8	

2N3806 thru 2N3810,A, 2N3811,A, 2N3812,A, 2N3816,A, 2N3817,A

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)			30	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)			100	500	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	8.0	pF
Input Impedance		h_{ie}			Ω
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3806,8,10,A,12,14,16,A		3.0	30	
	2N3807,9,11,A,13,15,17,A		10	40	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	—	25	X 10^{-4}
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3806,8,10,A,12,14,16,A		150	600	
	2N3807,9,11,A,13,15,17,A		300	900	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	5.0	60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_G = 3.0 kohms		NF			dB
f = 100 Hz, BW = 20 Hz	2N3806,8,10,A,12,14,16,A		—	7.0	
	2N3807,9,11,A,13,15,17,A		—	4.0	
Spot Noise f = 1.0 kHz, BW = 200 Hz	2N3806,8,10,A,12,14,16,A		—	3.0	
	2N3807,9,11,A,13,15,17,A		—	1.5	
f = 10 kHz, BW = 2.0 kHz)	2N3806,8,10,A,12,14,16,A		—	2.5	
	2N3807,9,11,A,13,15,17,A		—	1.5	
Broadband Noise Bandwidth	2N3806,8,10,A,12,14,16,A		—	3.5	
10 Hz to 15.7 kHz	2N3807,9,11,A,13,15,17,A		—	2.5	
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2)		h_{FE1}/h_{FE2}			—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3608,9,14,15		0.8	1.0	
	2N3810,11,16,17		0.9	1.0	
	2N3810A,11A,16A,17A		0.95	1.0	
(I_C = 100 μAdc, V_{CE} = 50 Vdc, T_A = −55 to +125°C)	2N3810A,11A,16A,17A		0.85	1.0	
Base-Emitter Voltage Differential		$\lvert V_{BE1}-V_{BE2} \rvert$			mVdc
(I_C = 10 μAdc to 10 mAdc, V_{CE} = 5.0 Vdc)	2N3808,9,14,15		—	8.0	
	2N3810,A,11,A,16,A,17,A		—	5.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3808,9,14,15		—	5.0	
	2N3810,11,16,17		—	3.0	
	2N3810A,11A,16A,17A		—	1.5	
Base-Emitter Voltage Differential Change Due to Temperature		$\Delta(V_{BE1}-V_{BE2})$			mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +25°C)	2N3808,9,14,15		—	1.6	
	2N3810,11,16,17		—	0.8	
	2N3810A,11A,16A,17A		—	0.4	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)	2N3808,9,14,15		—	2.0	
	2N3810,11,16,17		—	1.0	
	2N3810A,11A,16A,17A		—	0.5	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

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2N3806 thru 2N3810,A, 2N3811,A, 2N3812,A, 2N3816,A, 2N3817,A

FIGURE 1 — DC CURRENT GAIN versus COLLECTOR CURRENT

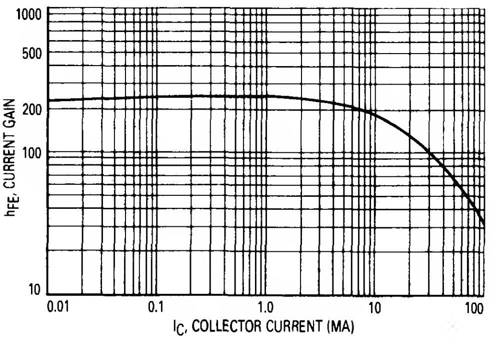


FIGURE 2 — DC CURRENT GAIN versus COLLECTOR CURRENT

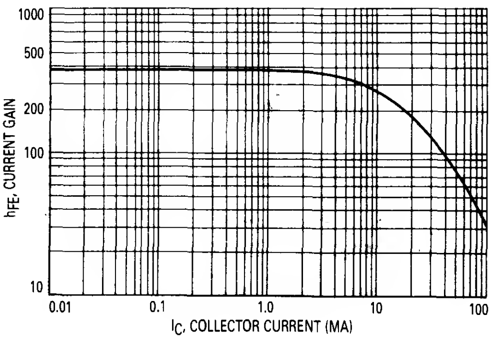


FIGURE 3 — "ON" VOLTAGES

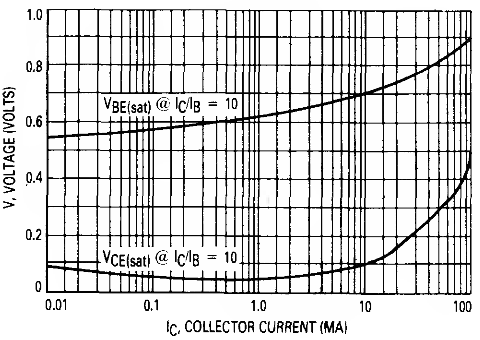
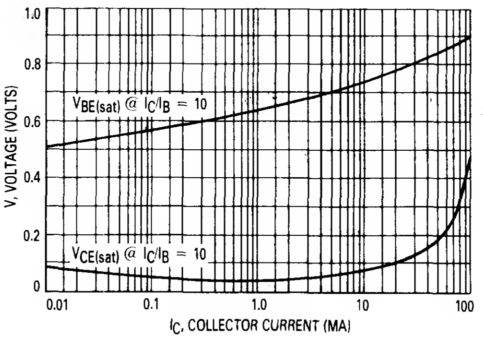


FIGURE 4 — "ON" VOLTAGES



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2N3838

CASE 610A-04, STYLE 1

COMPLEMENTARY DUAL AMPLIFIER TRANSISTOR

NPN/PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating any Lead to Case	V_{C1C2}	±120 ±120		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.25 1.67	0.35 2.34	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.7 4.67	1.4 9.34	Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Emitter Nonmatching Voltage ($I_{C(on)}$ = 600 mAdc, $I_{B(on)}$ = 120 mAdc, $I_{B(off)}$ = 0)	$V_{CEO(NL)}$†	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc)	I_{BEV}	—	10	nAdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc) (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc, T_A = 150°C)	I_{CEV}	— —	0.01 10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	h_{FE}	35 50 75 100 50	— — — 300 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	0.85	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.6	9.0	kohms
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	60	300	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	—	50	μmho
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)	NF	—	8.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 10 Vdc, $V_{BE(off)}$ = 0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	10	ns
Rise Time		t_r	—	40	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	250	ns
Fall Time		t_f	—	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

† The highest value of collector supply voltage that may be safely used with a resistive load switching circuit in which the collector current is 600 mAdc.

2N4015
2N4016

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

Refer to MD2905,A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating and Lead to Case	V_{C1C2}	±200 ±200		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Base Current	I_B	100		mAdc
Collector Current — Continuous	I_C	300		mAdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.29	500 2.86	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.85 4.85	1.4 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = +150°C)	I_{CBO}	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.01 mAdc, V_{CE} = 5.0 Vdc) (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)(1)	h_{FE}	 80 120 135 115	 — — 350 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, V_{CE} = 2.5 Vdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	 200 60	 600 —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	—	11.5	kohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	—	15	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	135	420	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	—	80	μmhos
Noise Figure (I_C = 0.03 mAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 1.0 kHz, BW = 200 Hz)		NF	—	4.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)		h_{FE1}/h_{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential (I_C = 0.1 to 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N4015	$\lvert V_{BE1}-V_{BE2}\rvert$	—	5.0	mVdc
	2N4016		—	2.5	
Base-Emitter Voltage Differential Gradient (I_C = 0.1 to 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +25°C)	2N4015	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	1.6	mVdc
	2N4016		—	0.8	
(I_C = 0.1 to 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = +25°C to +125°C)	2N4015		—	2.0	
	2N4016		—	1.0	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N4854
2N4855

2N4854 — JAN, JTX, JTXV AVAILABLE
CASE 654-07, STYLE 5

COMPLEMENTARY DUAL AMPLIFIER TRANSISTOR

NPN/PNP SILICON

5

Refer to MD6001 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating any Lead to Case	V_{C1C2}	±200 ±200		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	600 4.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 6.67	2.0 13.33	Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	—	10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N4854 2N4855		35 20	— —	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N4854 2N4855		50 25	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N4854 2N4855		75 35	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N4854 2N4855		100 40	300 120	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N4854 2N4855		50 20	— —	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1)	2N4854 2N4855		35 20	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	0.75	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	200	—	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4854 2N4855	h_{ie}	1.5 0.75	9.0 4.5	kohms
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4854 2N4855	h_{fe}	60 30	300 150	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4854 2N4855	h_{oe}	— —	50 25	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)		NF	—	8.0	dB

SWITCHING CHARACTERISTICS

		Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	20	ns
Rise Time		t_r	—	40	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	280	ns
Fall Time		t_f	—	70	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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2N4937 thru 2N4942

2N4937, 2N4938, 2N4939
CASE 654-07, STYLE 1
2N4440, 2N4441, 2N4442
CASE 610A-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MD3250,A for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating and Lead to Case	V_{C1C2}	±200 ±200		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Base Current	I_B	10		mAdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C — Ceramic Metal Can Derate above 25°C — Ceramic Metal Can	P_D	250 500 1.5 2.9	350 600 2.0 3.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C Metal Can	P_D	1.2 6.85	2.0 11.42	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40 50 50	200 250 250	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 Mhz)	f_T	300	900	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) Emitter Guarded	C_{cb}	—	5.0	pF
Input Impedance (I_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz) Collector Guarded	C_{eb}	—	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.0	10	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	—	10	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	—	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	5.0	50	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kΩ, f = 10 Hz to 15.7 kHz)	NF	—	4.0	dB

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(1) (I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc)	2N4937, 2N4941 2N4938, 2N4940	h_{FE1}/h_{FE2}	0.9 0.8	1.0 1.0	—
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc, T_A = −55°C to 125°C)	2N4937, 2N4941 2N4938, 2N4940		0.85 0.7	1.0 1.0	
Base-Emitter Voltage Differential (I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc)	2N4937, 2N4941 2N4938, 2N4940	$\lvert V_{BE1}-V_{BE2}\rvert$	— —	3.0 5.0	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C to +125°C)	2N4937, 2N4941 2N4938, 2N4940	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	— —	1.0 2.0	mVdc
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc, T_A = −55°C to 25°C)	2N4937, 2N4941 2N4938, 2N4940		— —	0.8 1.6	

(1) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

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2N5793
2N5794

JAN, JTX, JTXV AVAILABLE
CASE 654-07, STYLE 1

DUAL TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	75		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.9	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

Refer to MD2218,A for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	75	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)		I_{CBO}	—	10	nAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	10	nAdc
Collector 1 to Collector 2 Leakage Current ($V_{1C\text{-}2C} = \pm 50$ Vdc)		$I_{C1\text{-}C2}$	—	±1.0	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc)	2N5793		20	—	
	2N5794		35	—	
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	2N5793		25	—	
	2N5794		50	—	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)(1)	2N5793		35	—	
	2N5794		75	—	
($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	2N5793		20	—	
	2N5794		50	—	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1)	2N5793		40	120	
	2N5794		100	300	
($I_C = 300$ mAdc, $V_{CE} = 10$ Vdc)(1)	2N5793		25	—	
	2N5794		40	—	
Collector-Emitter Saturation Voltage(1)	($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)	$V_{CE(sat)}$	— —	0.3 0.9	Vdc
Base-Emitter Saturation Voltage(1)	($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)	$V_{BE(sat)}$	0.6 —	1.2 1.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	250	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{cb}	—	8.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{eb}	—	25	pF
SWITCHING CHARACTERISTICS					
Delay Time	($V_{CC} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc,	t_d	—	15	ns
Rise Time	$I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)	t_r	—	30	ns
Storage Time	($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc,	t_s	—	250	ns
Fall Time	$I_{B1} = I_{B2} = 15$ mAdc)	t_f	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N5795
2N5796

JAN, JTX, JTXV AVAILABLE
CASE 654-07, STYLE 1

DUAL TRANSISTOR

PNP SILICON

5

Refer to MD2904,A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	**Both Die Equal Power**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
Collector 1 to Collector 2 Leakage Current (V_{1C-2C} = ±50 Vdc		I_{C1-C2}	—	±1.0	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	2N5795 2N5796		40 75	— —	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N5795 2N5796		40 100	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N5795 2N5796		40 100	— —	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N5795 2N5796		20 50	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N5795 2N5796		40 100	120 300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N5795 2N5796		40 50	— —	
Collector-Emitter Saturation Voltage(1)	(I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	— —	0.4 1.6	Vdc
Base-Emitter Saturation Voltage(1)	(I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	— —	1.3 2.6	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	—	8.0	pF
Emitter-Base Capacitance (V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	—	30	pF
SWITCHING CHARACTERISTICS (See Figure 1)					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	12	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	100	ns
Fall Time		t_f	—	40	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

BFX11

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current – Continuous	I_C	100		mAdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400	500	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.85	1.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1)	(I_C = 10 mA, I_B = 0)	$V_{CEO(sus)}$		45	Vdc
Collector-Base Breakdown Voltage	(I_C = 10 μA, I_E = 0)	$V_{(BR)CBO}$		45	Vdc
Emitter-Base Breakdown Voltage	(I_C = 0, I_E = 10 μA)	$V_{(BR)EBO}$		4.5	Vdc
Collector Cutoff Current	(V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}		10 10	nAdc μAdc
Emitter Cutoff Current	(I_C = 0, V_{EB} = 3 Vdc)	I_{EBO}		100	nAdc
ON CHARACTERISTICS					
DC Current Gain	(I_C = 10 μA, V_{CE} = 5 Vdc) (I_C = 100 μA, V_{CE} = 5 Vdc) (I_C = 1 mA, V_{CE} = 5 Vdc) (I_C = 50 mA, V_{CE} = 5 Vdc)	h_{FE}	50 80 90 80	— — — —	— — — —
Collector-Emitter Saturation Voltage	(I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage	(I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product	(I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	130	—	MHz
Output Capacitance	(V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	8	pF
Input Capacitance	(V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	25	pF
Noise Figure	(I_C = 30 μAdc, V_{CE} = 5 Vdc, R_S = 10 kohms, f = 1 kHz)	NF	—	5	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2)	(I_C = 100 μAdc, V_{CE} = 5 Vdc)	h_{FE1}/h_{FE2}	0.8	1	—
Base-Emitter Voltage Differential	(I_C = 100 μAdc, V_{CE} = 5 Vdc)	$\lvert V_{BE1}-V_{BE2}\rvert$	—	5	mVdc
Base-Emitter Voltage Differential Gradient	(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = −55°C to +125°C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	20	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

BFX15

CASE 645-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	80		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current – Continuous	I_C	200		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500	600	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2	1.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1)	(I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	40		Vdc
Collector-Base Breakdown Voltage	(I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80		Vdc
Emitter-Base Breakdown Voltage	(I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0		Vdc
Collector-Emitter Sustaining Voltage(1)	(I_C = 100 mAdc, R_{BE} = 10 Ω)	$V_{CER(sus)}$	60		Vdc
Collector Cutoff Current	(V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}		10 10	nAdc μAdc
Emitter Cutoff Current	(V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}		10	nAdc
ON CHARACTERISTICS					
DC Current Gain	(I_C = 10 μAdc, V_{CE} = 5 Vdc) (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	30 60 90	— — —	— — —
Collector-Emitter Saturation Voltage	(I_C = 1 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage	(I_C = 1 mAdc, I_B = 0.1 mAdc)	$V_{BE(sat)}$	—	0.6	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product	(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance	(V_{CB} = 10 Vdc, I_E = 0, f = 1 kHz)	C_{obo}	—	15	pF
Input Capacitance	(V_{EB} = 0.5 Vdc, I_C = 0, f = 1 kHz)	C_{TE}	—	85	pF
Small-Signal Current Gain	(I_C = 1 mAdc, V_{CE} = 5.0 Vdc, f = 1 kHz)	h_{FE}	30	—	—
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2)	(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	h_{FE1}/h_{FE2}	0.9	1	– –
Base-Emitter Voltage Differential	(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	$\lvert V_{BE1}-V_{BE2}\rvert$	—	5.0	mVdc
Base-Emitter Voltage Differential Gradient	(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = –55°C to +125°C) ($I_{C1} + I_{C2}$ = 200 μAdc, T_A = 0°C to +70°C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	10 2.5	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

BFX36

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	6		Vdc
Collector Current – Continuous	I_C	100		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400	600	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.8	1.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1)	($I_C = 5$ mA, $I_B = 0$)	$V_{CEO(sus)}$		60	Vdc
Collector-Base Breakdown Voltage	($I_C = 10$ μA, $I_E = 0$)	$V_{(BR)CBO}$		60	Vdc
Emitter-Base Breakdown Voltage	($I_E = 10$ μA, $I_C = 0$)	$V_{(BR)EBO}$		6	Vdc
Collector Cutoff Current	($V_{CB} = 50$ V, $I_E = 0$) ($V_{CB} = 50$ V, $I_E = 0$, $T_A = 125°C$)	I_{CBO}		10 10	nAdc μAdc
Emitter Cutoff Current	($V_{EB} = 4$ V, $I_C = 0$)	I_{EBO}		10	nAdc
ON CHARACTERISTICS					
DC Current Gain	($I_C = 1$ μAdc, $V_{CE} = 5$ V) ($I_C = 10$ μAdc, $V_{CE} = 5$ Vdc) ($I_C = 100$ μAdc, $V_{CE} = 5$ Vdc) ($I_C = 1$ mAdc, $V_{CE} = 5$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 5$ Vdc) ($I_C = 10$ μAdc, $V_{CE} = 5$ Vdc, $T_A = -55°C$)	h_{FE}	60 100 100 100 90 40	— 300 — — — —	— — — — — —
Collector-Emitter Saturation Voltage Base-Emitter Saturation Voltage	($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)	$V_{CE(sat)}$ $V_{BE(sat)}$	— —	0.25 0.9	Vdc
Collector-Emitter Saturation Voltage Base-Emitter Saturation Voltage	($I_C = 50$ mAdc, $I_B = 5$ mAdc)	$V_{CE(sat)}$ $V_{BE(sat)}$	— —	0.4 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product	($I_C = 1$ mAdc, $V_{CE} = 5$ Vdc, f = 20 MHz)	f_T	40	—	MHz
Output Capacitance	($V_{CB} = 5$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	6	pF
Input Impedance	($I_C = 1$ mAdc, $V_{CE} = 5$ Vdc, f = 1 kHz)	h_{ie}	2.5	20	kohm
Voltage Feedback Ratio	($I_C = 1$ mAdc, $V_{CE} = 5$ Vdc, f = 1 kHz)	h_{re}	—	10	$\times 10^{-4}$
Output Admittance	($I_C = 1$ mAdc, $V_{CE} = 5$ Vdc, f = 1 kHz)	h_{oe}	5	50	μmhos
Noise Figure (3)	($I_C = 20$ μAdc, $V_{CE} = 5$ Vdc, $R_S = 10$ kohms, f = 1 kHz)	NF	—	3	dB
Noise Figure (4)	($I_C = 20$ μAdc, $V_{CE} = 5$ Vdc, $R_S = 10$ kohms, f = 1 kHz)	NF	—	10	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2)	($I_C = 100$ μAdc, $V_{CE} = 5$ Vdc)	h_{FE1}/h_{FE2}	0.9	—	—
Base-Emitter Voltage Differential	($I_C = 100$ μAdc, $V_{CE} = 5$ Vdc)	$\lvert V_{BE1}-V_{BE2}\rvert$	—	3	mVdc
Base-Emitter Voltage Differential Gradient	($I_C = 100$ μAdc, $V_{CE} = 5$ Vdc, $T_A = -55°C$ to $+125°C$)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	10	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.
(3) BW = 200 Hz
(4) BW = 20 Hz

BFY81

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	6		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1)	$V_{CEO(sus)}$	45	—	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	45	—	Vdc
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	6	—	Vdc
Collector Cutoff Current ($I_E = 0$, $V_{CB} = 40$ Vdc) ($I_E = 0$, $V_{CB} = 40$ Vdc, $T_A = 150°C$)	I_{CBO}		10 10	nAdc µAdc
Emitter Cutoff Current ($I_C = 0$, $V_{EB} = 5.0$ Vdc)	I_{EBO}		10	nAdc
Collector to Emitter Cutoff Current ($V_{CE} = 5.0$ Vdc, $I_B = 0$)	I_{CEO}		10	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ µA, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ µA, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mA, $V_{CE} = 5.0$ Vdc)	h_{FE}	60 100 150	— — —	— — —
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	—	0.35	Vdc
Base-Emitter ON Voltage ($I_C = 100$ µAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(ON)}$	—	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 500$ µAdc, $V_{CE} = 5.0$ Vdc, f = 30 MHz)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	6.0	pF
Noise Figure ($I_C = 10$ µAdc, $V_{CE} = 5.0$ Vdc, $R_S = 2$ kohms, f = 1 kHz)	NF	—	4.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) ($I_C = 100$ µAdc, $V_{CE} = 5.0$ Vdc)	h_{FE1}/h_{FE2}	0.8	1	—
Base-Emitter Voltage Differential ($I_C = 100$ µAdc, $V_{CE} = 5.0$ Vdc)	$\lvert V_{BE1}-V_{BE2}\rvert$	—	10	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 100$ µAdc, $V_{CE} = 5$ Vdc, $T_A = -55°C$ to $+125°C$)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	25	µV/°C

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

BFY84

CASE 654-07

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	12		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3		Vdc
Collector Current – Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 3.0 mA, I_B = 0)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μA, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150 °C)	I_{CBO}	— —	10 1	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1 Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	—	MHz
Output Capacitance (V_{CB} = 0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	3.0	pF
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{TE}	—	2.0	pF
Noise Figure (I_C = 1 mA, V_{CE} = 6.0 Vdc, R_S = 0.4 kohms, f = 60 MHz)	NF	—	6.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE1}/h_{FE2}	0.8	1	–
Base-Emitter Voltage Differential (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	$\|V_{BE1}-V_{BE2}\|$	—	15	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 3.0 mAdc, V_{CE} = 1 Vdc, T_A = −55 °C to +125 °C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	25	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD708,A,B

CASE 654-07, STYLE 1

MD708F,AF,BF

CASE 610A-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD2369 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD708, MD708A, MD708B		550	600	
MD708F, MD708AF, MD708BF		350	400	
Derate above 25°C				mW/°C
MD708, MD708A, MD708B		3.13	3.42	
MD708F, MD708AF, MD708BF		2.0	2.28	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD708, MD708A, MD708B		1.4	2.0	
MD708F, MD708AF, MD708BF		0.7	1.4	
Derate above 25°C				mW/°C
MD708, MD708A, MD708B		8.0	11.4	
MD708F, MD708AF, MD708BF		4.0	8.0	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD708, MD708A, MD708B		125	87.5	
MD708F, MD708AF, MD708BF		250	125	
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	319	292	°C/W
		500	438	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD708, MD708A, MD708B		83	40	
MD708F, MD708AF, MD708BF		75	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 30$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	15	nAdc
($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 150°C$)		—	30	μAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 500$ μAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	40	—	—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)		40	200	
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		35	—	
($I_C = 150$ mAdc, $V_{CE} = 5.0$ Vdc)		20	—	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.20	Vdc
($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		—	0.35	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)		—	0.50	
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		—	0.95	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)		—	1.10	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MD918
MD918A
MD918B

CASE 654-07, STYLE 1

MD918F
MD918AF
MD918BF

CASE 610A-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ T_A = 25°C MD918,A,B MD918F,AF,BF Derate above 25°C MD918,A,B MD918F,AF,BF	P_D	 550 350 3.14 2.0	 600 400 3.42 2.28	 mW mW/°C
Total Device Dissipation @ T_C = 25°C MD918,A,B MD918F,AF,BF Derate above 25°C MD918,A,B MD918F,AF,BF	P_D	 1.4 0.7 8.0 4.0	 2.0 1.4 11.4 8.0	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	MD918,A,B MD918F,AF,BF	$R_{\theta JC}$	125 250	87.5 125	°C/W
Thermal Resistance, Junction to Ambient	MD918,A,B MD918F,AF,BF	$R_{\theta JA}$(1)	319 500	292 438	°C/W
			Junction to Ambient	**Junction to Case**	
Coupling Factors	MD918,A,B MD918F,AF,BF		83 75	40 0	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 — —	 10 1.0	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	165	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 Adc)	$V_{CE(sat)}$	—	0.09	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.86	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	1.1	1.7	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	1.15	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400Ω, f = 60 MHz)		NF	—	—	6.0	dB
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(3) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MD918B,BF MD918A,AF	h_{FE1}/h_{FE2}	0.8 0.9	— —	1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MD918B,BF MD918A,AF	$\lvert V_{BE1}-V_{BE2}\rvert$	— —	— —	10 5.0	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +125°C)	MD918B,AF,BF MD918A	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	— —	— —	20 10	µV/dc °C

(2) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

FIGURE 1 – DC CURRENT GAIN

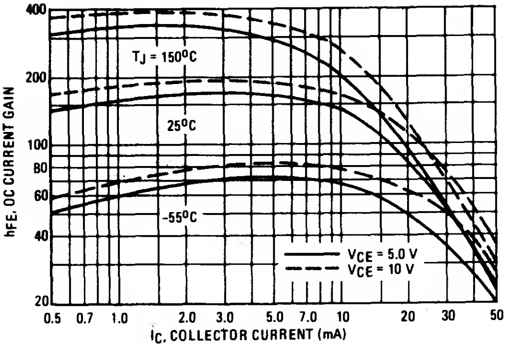


FIGURE 2 – "ON" VOLTAGES

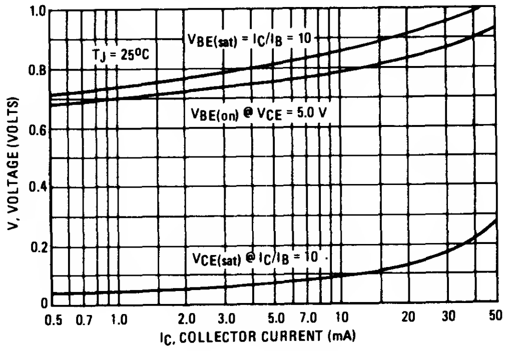


FIGURE 3 – BASE-EMITTER TEMPERATURE COEFFICIENT

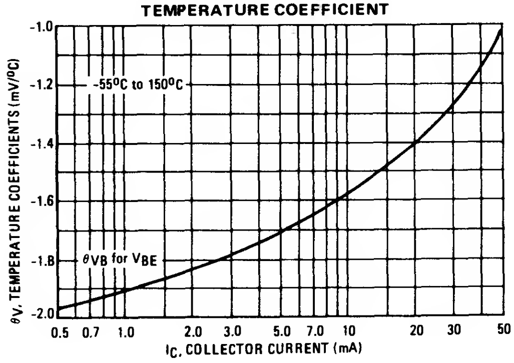


FIGURE 4 – CURRENT-GAIN BANDWIDTH PRODUCT

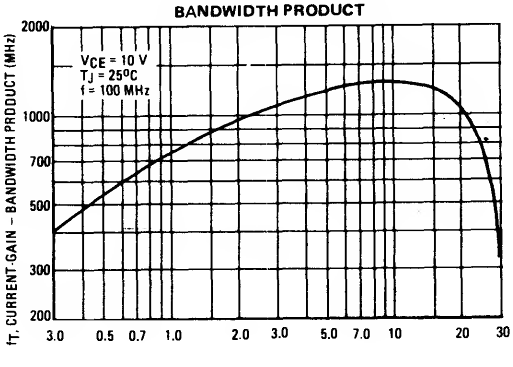
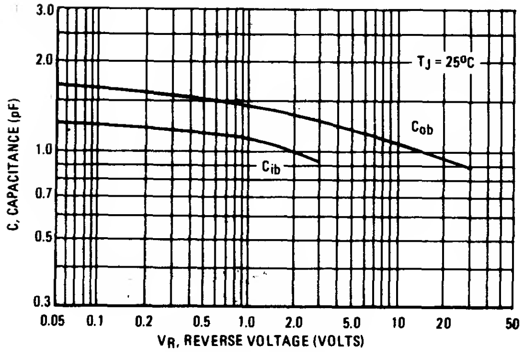


FIGURE 5 – CAPACITANCE



MD2218,A,F,AF
MD2219,A,F,AF
MQ2218,A
MQ2219,A

MD2218,A
MD2219,A
CASE 654-07, STYLE 1

MD2218F,AF
MD2219F,AF
CASE 610A-04, STYLE 1

MQ2218,A
MQ2219,A
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	MD2218,A,F MD2219,A,F MQ2218,A MQ2219,A	MD2218AF MD2219AF	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	**All Die Equal Power**	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD2218,A, MD2219,A		575	625	
MD2218F,AF, MD2219F,AF		350	400	
MQ2218,A, MQ2219,A		400	600	
Derate above 25°C				mW/°C
MD2218,A, MD2219,A		3.29	3.57	
MD2218F,AF, MD2219F,AF		2.0	2.28	
MQ2218,A, MQ2219,A		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD2218,A, MD2219,A		1.8	2.5	
MD2218F,AF, MD2219F,AF		1.0	2.0	
MQ2218,A, MQ2219,A		0.9	3.6	
Derate above 25°C				mW/°C
MD2218,A, MD2219,A		10.3	14.3	
MD2218F,AF, MD2219F,AF		5.71	11.4	
MQ2218,A, MQ2219,A		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD2218,A, MD2219,A		97	70	
	MD2218F,AF, MD2219F,AF		175	87.5	
	MQ2218,A, MQ2219,A		195	48.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD2218,A, MD2219,A		304	280	
	MD2218,F,AF, MD2219,F,AF		500	438	
	MQ2218,A, MQ2219,A		438	292	
			Junction to Ambient	**Junction to Case**	
Coupling Factors					%
	MD2218,A, MD2219,A		84	44	
	MD2218F,AF, MD2219F,AF		75	0	
	MQ2218,A, MQ2219,A (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$				Vdc
	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		30	—	—	
	MD2218AF, MD2219AF		40	—	—	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$				Vdc
	MD2218,A,F, MD2219,A,F, MQ2218,A, MD2219,A		60	—	—	
	MD2218AF, MD2219AF		75	—	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A	$V_{(BR)EBO}$	5.0	—	—	Vdc
	MD2218AF, MD2219AF		6.0	—	—	
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MD2218,F, MD2219,F, MQ2218,A	I_{CEV}	20	—	—	nAdc
	MD2218A,AF, MD2219A,AF, MQ2219,A		15	—	—	
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		I_{BL}	30	—	—	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD2218,A,F,AF, MQ2218,A	h_{FE}	20	50	—	—
	MD2219,A,F,AF, MQ2219,A		35	45	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD2218,A,F,AF, MQ2218,A		25	55	—	
	MD2219,A,F,AF, MQ2219,A		50	55	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD2218,A,F,AF, MQ2218,A		35	65	—	
	MD2219,A,F,AF, MQ2219,A		75	85	—	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	MD2218,A,F,AF, MQ2218,A		20	65	—	
	MD2219,A,F,AF, MQ2219,A		50	65	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD2218,AF,AF, MQ2218,A		40	30	120	
	MD2219,A,F,AF, MQ2219,A		100	120	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MD2218,A, MQ2218,A		25	75	—	
	MD2219,A, MQ2219,A		30	75	—	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A	$V_{CE(sat)}$	—	0.2	0.4	Vdc
	MD2218AF, MD2219AF		—	—	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		—	0.35	1.2	
	MD2218AF, MD2219AF		—	—	0.9	
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A	$V_{BE(sat)}$	0.6	0.95	1.3	Vdc
	MD2218AF, MD2219AF		0.6	1.0	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		—	—	2.0	
	MD2218AF, MD2219AF		—	—	1.8	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	3.5	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A	C_{ibo}	—	15	20	pF
	MD2218AF, MD2219AF		—	18	25	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = 15 mAdc) MD2218,F, MD2219,F	t_d	—	—	20	μs
	MD2218A,AF, MD2219A,AF		—	—	15	
Rise Time	MD2218,F, MD2219,F	t_r	—	—	40	μs
	MD2218A,AF, MD2219A,AF		—	—	30	
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) MD2218,F, MD2219,F	t_s	—	—	280	μs
	MD2218A,AF, MD2219A,AF		—	—	250	
Fall Time	MD2218,F, MD2219,F	t_f	—	—	70	μs
	MD2218A,AF, MD2219A,AF		—	—	60	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

FIGURE 1 – NORMALIZED DC CURRENT GAIN

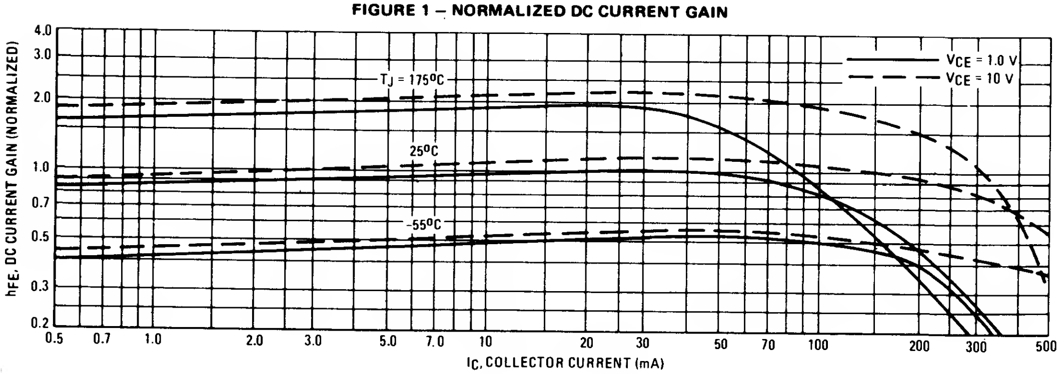


FIGURE 2 – "ON" VOLTAGES

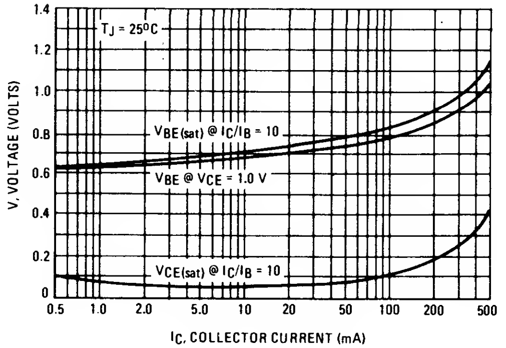
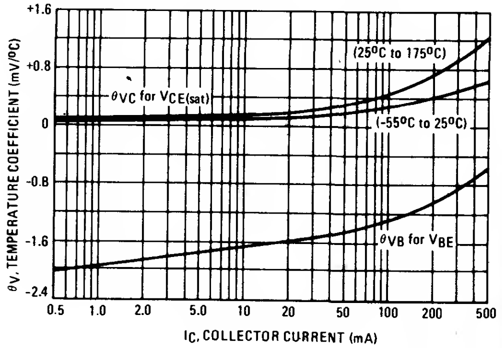


FIGURE 3 – TEMPERATURE COEFFICIENTS



NOISE FIGURE

(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 4 – FREQUENCY EFFECTS

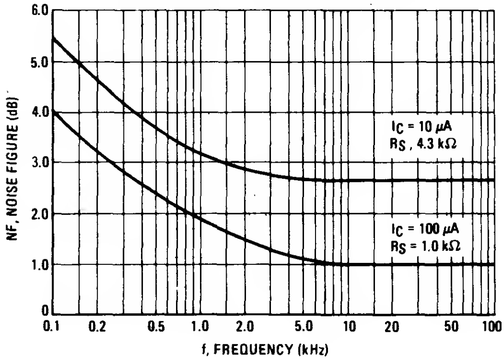


FIGURE 5 – SOURCE RESISTANCE EFFECTS

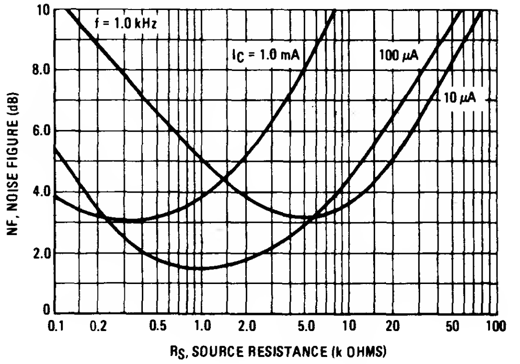


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT

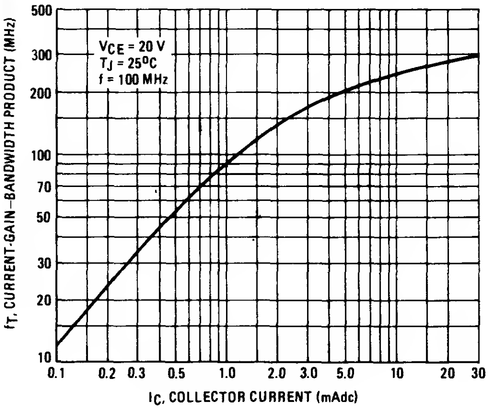
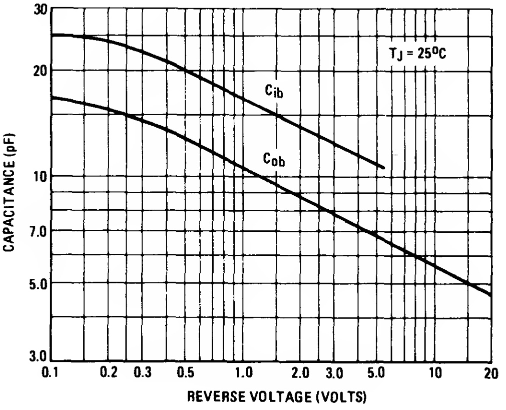


FIGURE 7 – CAPACITANCES



SWITCHING TIME CHARACTERISTICS

FIGURE 8 – TURN-ON TIME

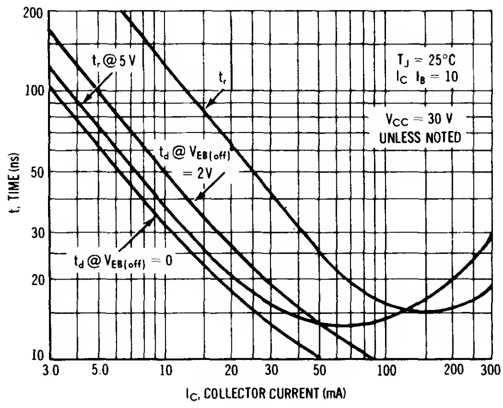


FIGURE 9 – CHARGE DATA

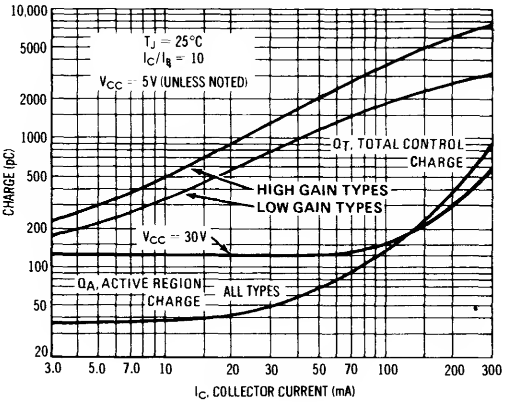


FIGURE 10 – TURN-OFF BEHAVIOR

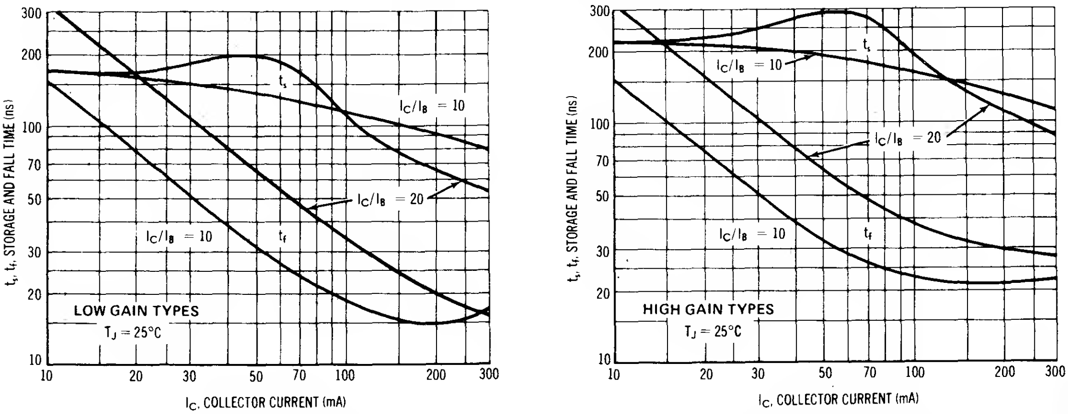


FIGURE 11 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

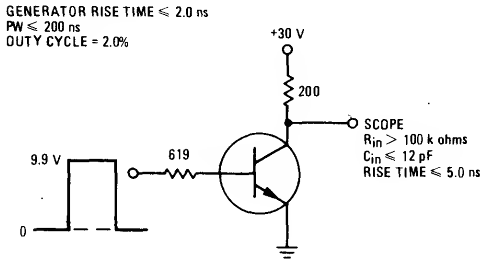
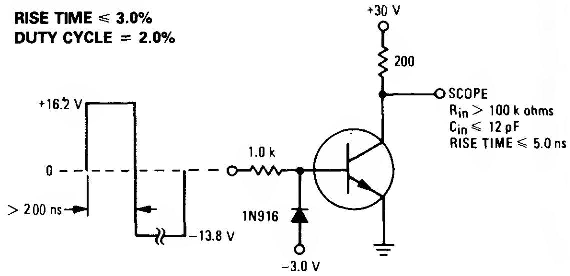


FIGURE 12 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD2369,A,B		550	600	
MD2369F,AF,BF		350	400	
MQ2369		400	600	
Derate above 25°C				mW/°C
MD2369,A,B		3.14	3.42	
MD2369F,AF,BF		2.0	2.28	
MQ2369		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD2369,A,B		1.4	2.0	
MD2369F,AF,BF		0.7	1.4	
MQ2369		0.7	2.8	
Derate above 25°C				mW/°C
MD2369,A,B		8.0	11.4	
MD2369F,AF,BF		4.0	80	
MQ2369		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

MD2369,A,B
MD2369F,AF,BF
MQ2369

MD2369,A,B
CASE 654-07, STYLE 1

MD2369F,AF,BF
CASE 610A-04, STYLE 1

MQ2369
CASE 607-04, STYLE 1

DUAL
GENERAL PURPOSE TRANSISTOR

NPN SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD2369,A,B		125	87.5	
	MD2369F,AF,BF		250	125	
	MQ2369		250	62.6	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD2369,A,B		319	292	
	MD2369F,AF,BF		500	438	
	MQ2369		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factor	MD2369,A,B		83	40	%
	MD2369F,AF,BF		75	0	
	MQ2369 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				μAdc
(V_{CB} = 20 Vdc, I_E = 0)		—	—	0.03	
(V_{CB} = 20 Vdc, I_E = 0, T_A = +150°C)		—	—	30	
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		40	95	140	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)		20	—	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	0.7	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	500	800	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	—	4.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 MHz)		C_{ibo}	—	—	4.0	pF
SWITCHING CHARACTERISTICS						
Storage Time (V_{CC} = 10 Vdc, I_C = I_{B1} = I_{B2} = 10 mAdc)		t_s	—	—	13	ns
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)		t_{on}	—	—	15	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)		t_{off}	—	—	20	ns
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(3) (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	MD2369A, MD2369AF	h_{FE1}/h_{FE2}	0.9	—	1.0	—
	MD2369B, MD2369BF		0.8	—	1.0	
Base-Emitter Voltage Differential (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	MD2369A, MD2369AF	$\|V_{BE1}-V_{BE2}\|$	—	—	5.0	mVdc
	MD2369B, MD2369BF		—	—	10	
Base-Emitter Voltage Differential Gradient (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc, T_A = −55 to +125°C)	MD2369A, MD2369AF	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	—	10	µV/°C
	MD2369B, MD2369BF		—	—	20	

(2) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this test.

FIGURE 1 — STORAGE TIME TEST CIRCUIT

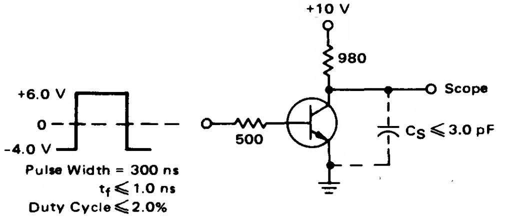


FIGURE 2 — TURN-ON TIME

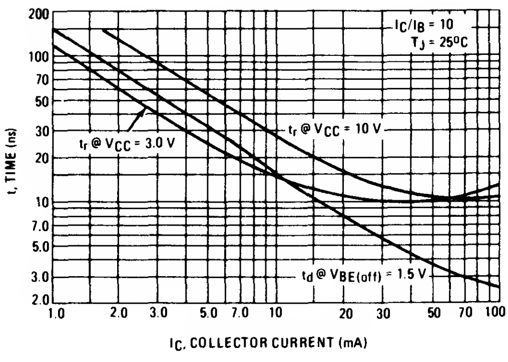


FIGURE 3 — TURN-OFF TIME

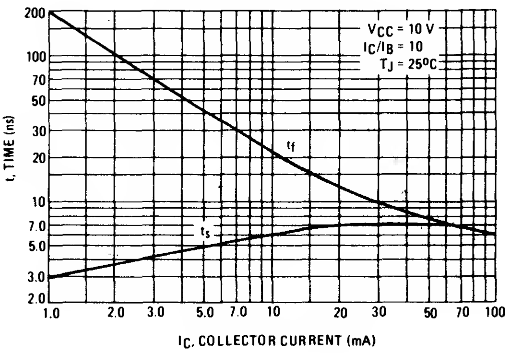


FIGURE 4 – TURN-ON TEST CIRCUIT

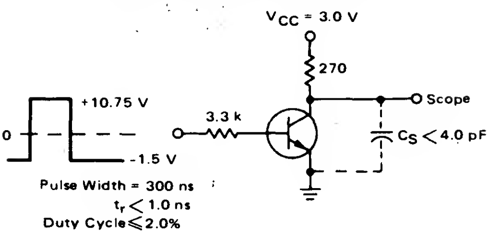


FIGURE 5 – TURN-OFF TEST CIRCUIT

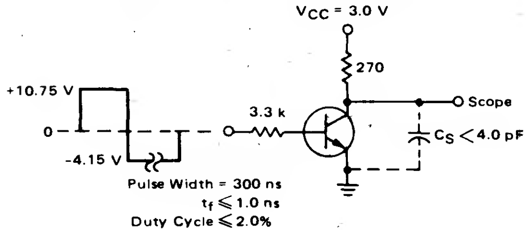


FIGURE 6 – CAPACITANCE

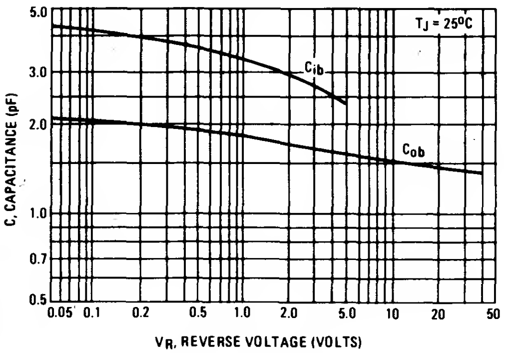


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

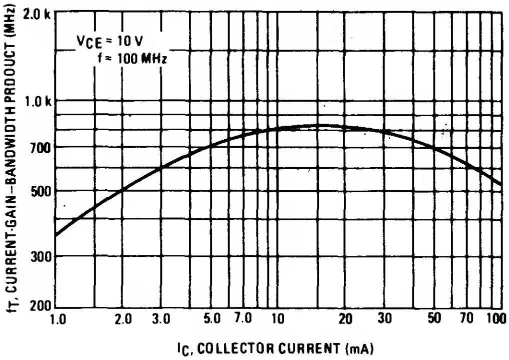


FIGURE 8 – DC CURRENT GAIN

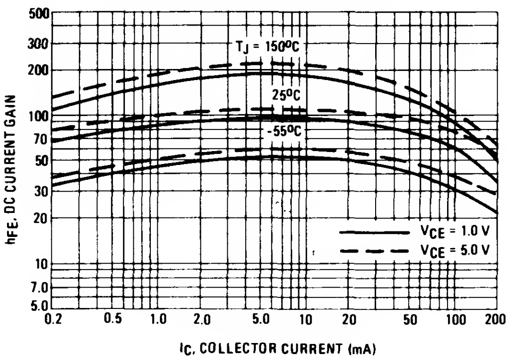


FIGURE 9 – "ON" VOLTAGES

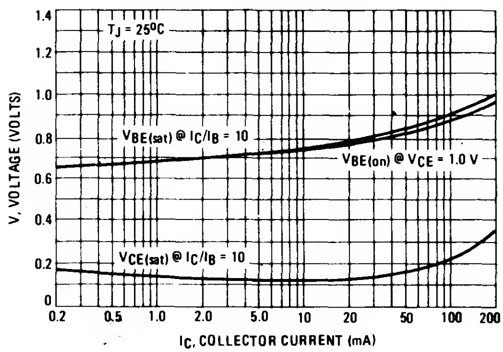


FIGURE 10 – COLLECTOR SATURATION REGION

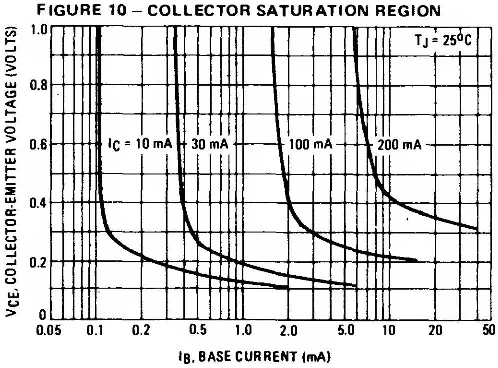
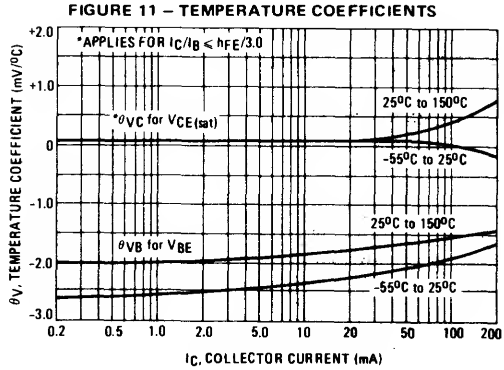


FIGURE 11 – TEMPERATURE COEFFICIENTS



MD2904,A,F,AF
MD2905,A,F,AF
MQ2904, MQ2905A

MD2904,A
MD2905,A
CASE 654-07, STYLE 1

MD2904F,AF
MD2905F,AF
CASE 610A-04, STYLE 1

MQ2904
MQ2905A
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	MD2904,F MD2905,F MQ2904	MD2904A,AF MD2905A,AF MQ2905A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	**All Die Equal Power**	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD2904,A, MD2905,A		575	625	
MD2904F,AF, MD2905,AF		350	400	
MQ2904, MQ2905A		400	600	
Derate above 25°C				mW/°C
MD2904,A, MD2905,A		3.29	3.57	
MD2904,F,AF, MD2905F,AF		2.0	2.28	
MQ2904, MQ2905A		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD2904,A, MD2905,A		1.8	2.5	
MD2904F,AF, MD2905F,AF		1.0	2.0	
MQ2904, MQ2905A		0.9	3.6	
Derate above 25°C				mW/°C
MD2904,A, MD2905,A		10.3	14.3	
MD2904F,AF, MD2905F,AF		5.71	11.4	
MQ2904, MQ2905A		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD2904,A, MD2905,A		97	70	
	MD2904F,AF, MD2905F,AF		175	87.5	
	MQ2904, MQ2905A		195	48.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD2904,A, MD2905,A		304	280	
	MD2904F,AF, MD2905F,AF		500	438	
	MQ2904, MQ2905A		438	292	
			Junction to Ambient	**Junction to Case**	
Coupling Factor					%
	MD2904,A, MD2905,A		84	44	
	MD2904F,AF, MD2905F,AF		75	0	
	MQ2904, MQ2905A (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	MD2904, MD2905	$V_{(BR)CEO}$	40	—	—	Vdc
	MD2904A, MD2905A		60	—	—	
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)		I_{CBO}	—	—	0.020	μAdc
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)			—	—	30	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	30	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD2904		20	50	—	
	MD2904A		40	70	—	
	MD2905		35	70	—	
	MD2905A		75	150	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD2904		25	75	—	
	MD2904A		40	75	—	
	MD2905		50	100	—	
	MD2905A		100	175	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD2904		35	90	—	
	MD2904A		40	90	—	
	MD2905		75	110	—	
	MD2905A		100	200	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD2904,A,		40	90	120	
	MD2905,A		100	200	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MD2904		20	60	—	
	MD2904A		40	80	—	
	MD2905		30	130	—	
	MD2905A		50	150	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.25	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.5	1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.88	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.0	2.6	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(3) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	320	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	16	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 30 Vdc, V_{BE} = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	—	—	45	ns
Delay Time		t_d	—	—	12	ns
Rise Time		t_r	—	—	35	ns
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	—	130	ns
Storage Time		t_s	—	—	100	ns
Fall Time		t_f	—	—	40	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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FIGURE 1 – DC CURRENT GAIN

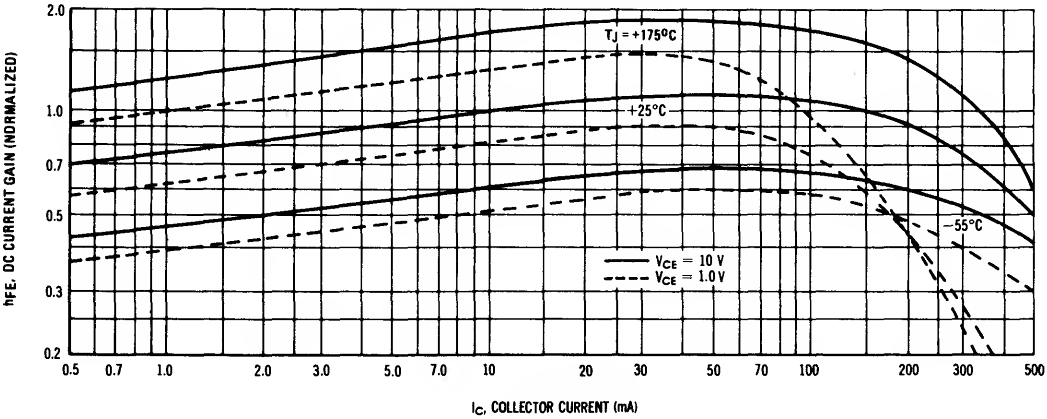

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FIGURE 2 – "ON" VOLTAGES

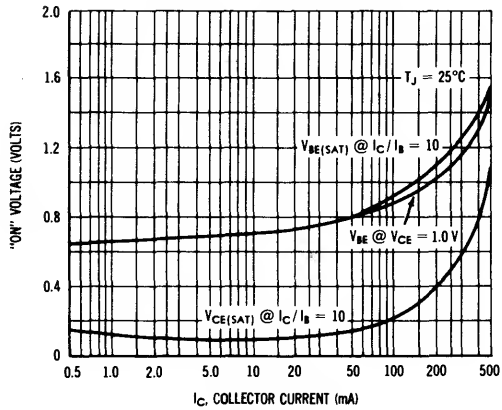
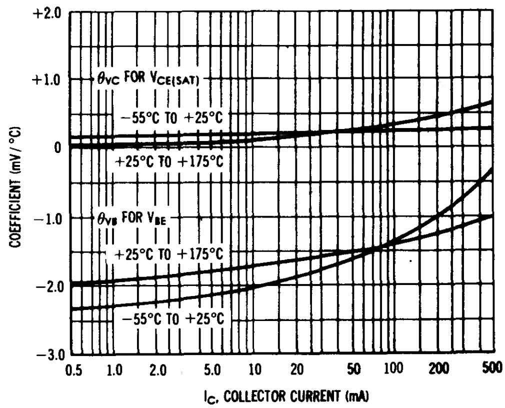


FIGURE 3 – TEMPERATURE COEFFICIENTS



NOISE FIGURE

V_{CE} = 10 V, T_A = 25°C

FIGURE 4 – FREQUENCY EFFECTS

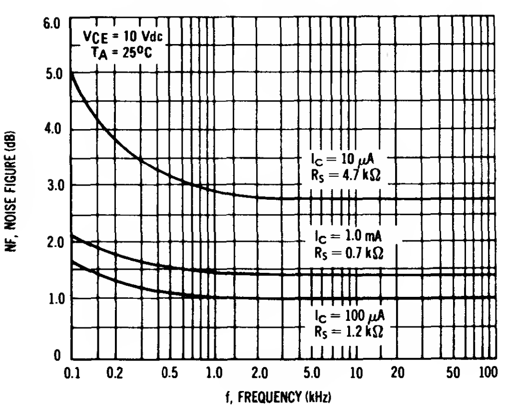


FIGURE 5 – SOURCE RESISTANCE EFFECTS

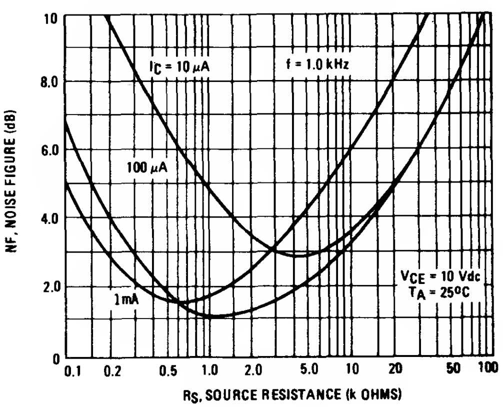


FIGURE 6 – CURRENT-GAIN BANDWIDTH PRODUCT

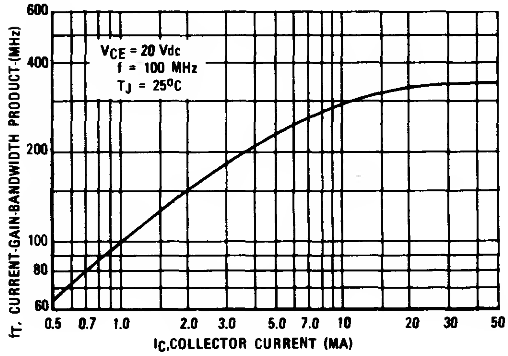


FIGURE 7 – CAPACITANCE

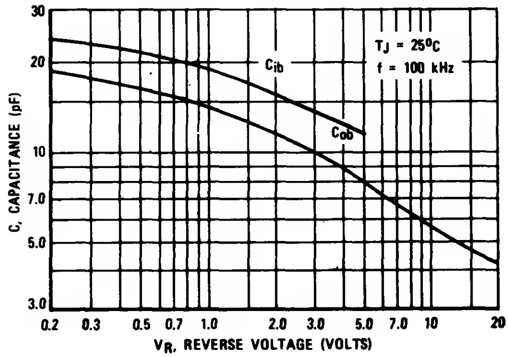


FIGURE 8 – TURN ON TIME

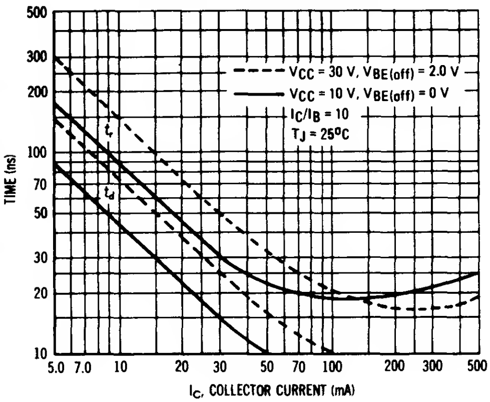


FIGURE 9 – CHARGE DATA

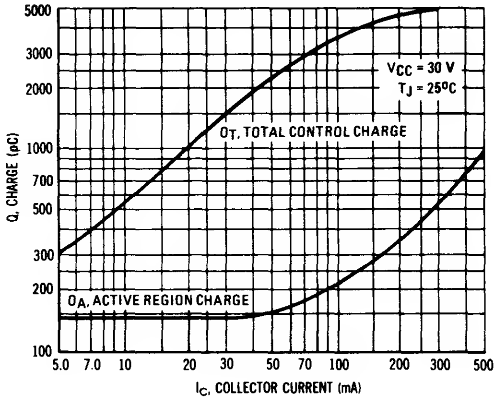


FIGURE 10 – STORAGE TIME

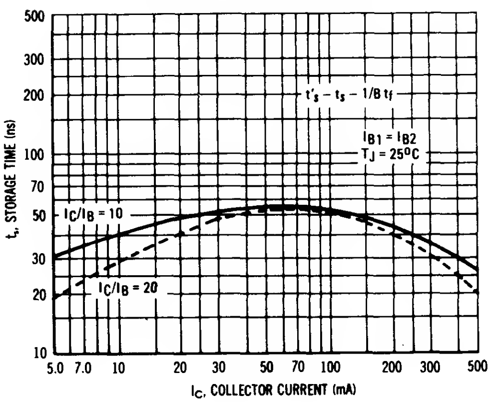


FIGURE 11 – FALL TIME

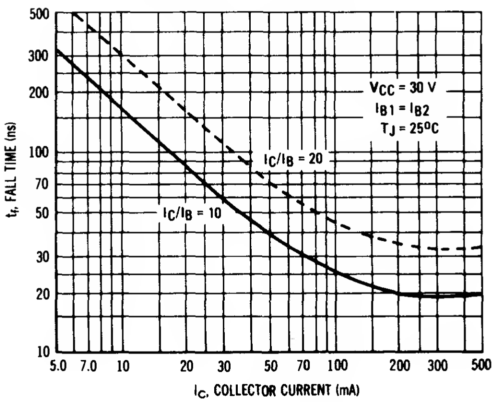


FIGURE 12 – DELAY AND RISE TIME TEST CIRCUIT

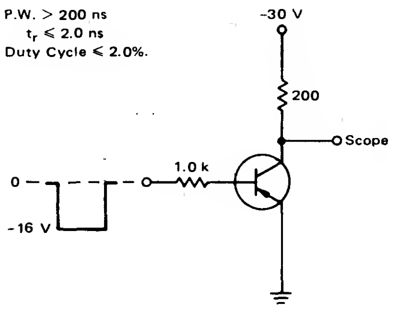
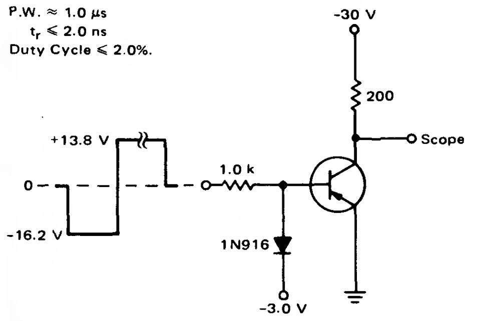


FIGURE 13 – STORAGE AND FALL TIME TEST CIRCUIT



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MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD3250,A, MD3251,A		575	625	
MD3250F,AF, MD3251F,AF		350	400	
MQ3251		400	600	
Derate above 25°C				mW/°C
MD3250,A, MD3251,A		3.29	3.57	
MD3250F,AF, MD3251F,AF		2.0	2.28	
MQ3251		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD3250,A, MD3251,A		1.8	2.5	
MD3250F,AF, MD3251F,AF		1.0	2.0	
MQ3251		0.9	3.6	
Derate above 25°C				mW/°C
MD3250,A, MD3251,A		10.3	14.3	
MD3250F,AF, MD3251F,AF		5.71	11.4	
MQ3251		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

MD3250,A,F,AF
MD3251,A,F,AF
MQ3251

MD3250,A
MD3251,A
CASE 654-07, STYLE 1

MD3250F,AF
MD3251F,AF
CASE 610A-04, STYLE 1

MQ3251
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD3251,A, MD3251,A		97	70	
	MD3250F,AF, MD3251F,AF		175	87.5	
	MQ3251		195	48.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD3250,A, MD3251,A		304	280	
	MD3250F,AF, MD3251F,AF		500	438	
	MQ3251		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factors					%
	MD3250,A, MD3251,A		84	44	
	MD3250F,AF, MD3251F,AF		75	0	
	MQ3251 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 40 Vdc, I_E = 0)		—	—	10	nAdc
(V_{CB} = 40 Vdc, I_E = 0, T_A = 150°C)		—	—	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	10	nAdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)						
DC Current Gain		h_{FE}				—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		25	75	—	
	MD3251,A,F,AF		50	100	—	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		50	82	150	
	MD3251,A,F,AF		80	170	300	
	MQ3251		80	170	—	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)	MD3250,A,F,AF		25	35	—	
	MD3251,A,F,AF		50	75	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		50	87	150	
	MD3251,A,F,AF		100	180	300	
	MQ3251		100	180	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		50	92	—	
	MD3251,A,F,AF		100	190	—	
	MQ3251		100	190	300	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		15	50	—	
	MD3251,A,F,AF		30	90	—	
	MQ3251		30	90	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	0.11	0.25	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.18	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.6	0.78	0.9	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.88	1.2	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MD3250,A,F,AF		200	600	—	
	MD3251,A,F,AF		250	600	—	
	MQ3251		300	600	—	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	2.5	6.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	6.0	8.0	pF
MATCHING CHARACTERISTICS (MD3250,A,F,AF & MD3251,A,F,AF ONLY)						
DC Current Gain Ratio(3)		h_{FE1}/h_{FE2}				—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			0.9	—	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)			0.9	—	1.0	
Base-Emitter Voltage Differential		$\|V_{BE1}-V_{BE2}\|$				mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			—	—	3.0	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)			—	—	5.0	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			—	—	5.0	
Base-Emitter Voltage Differential Change Due to Temperature		$\Delta\|V_{BE1}/V_{BE2}\|$				mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +25°C)			—	—	0.8	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)			—	—	1.0	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

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FIGURE 1 – CAPACITANCE

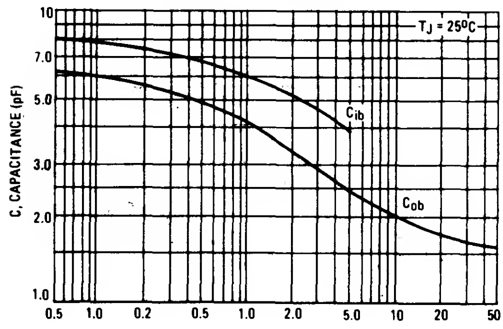
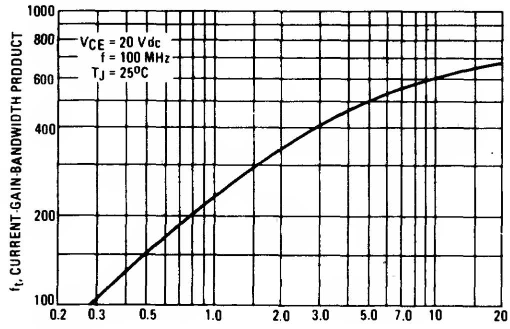


FIGURE 2 – CURRENT-GAIN BANDWIDTH PRODUCT



NOISE FIGURE VARIATIONS

(V_{CE} = 6.0 V, T_A = 25°C)

FIGURE 3 – EFFECTS OF FREQUENCY

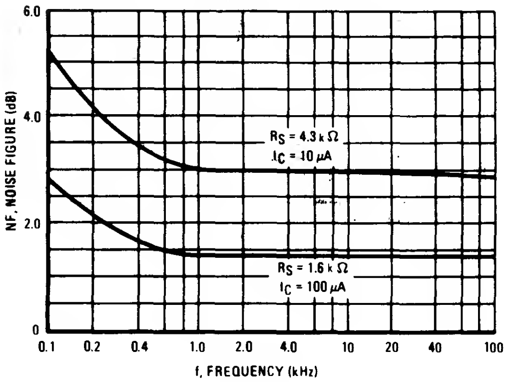


FIGURE 4 – EFFECTS OF SOURCE RESISTANCE

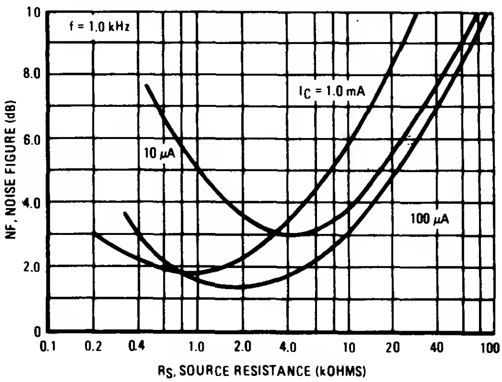


FIGURE 5 – DC CURRENT GAIN

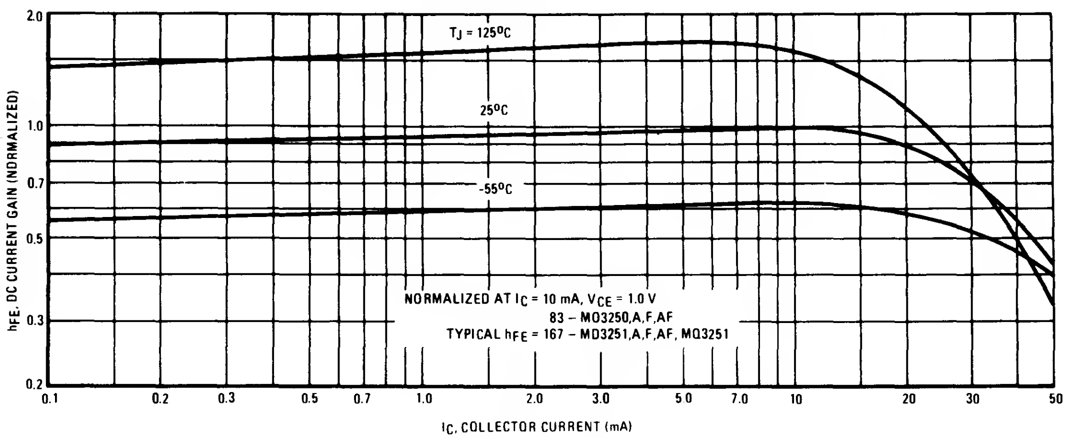


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FIGURE 6 – "ON" VOLTAGE

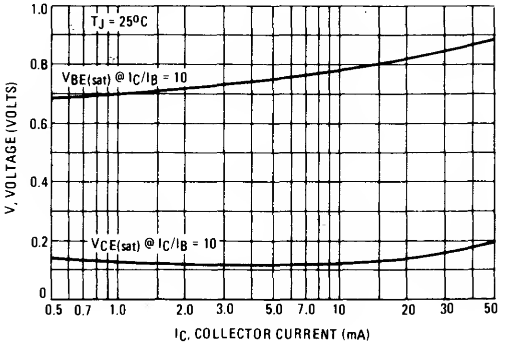

FIGURE 7 – TEMPERATURE COEFFICIENTS

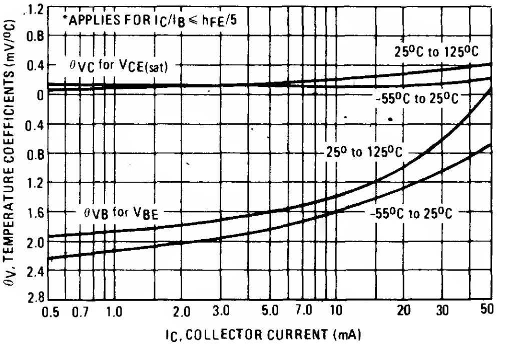

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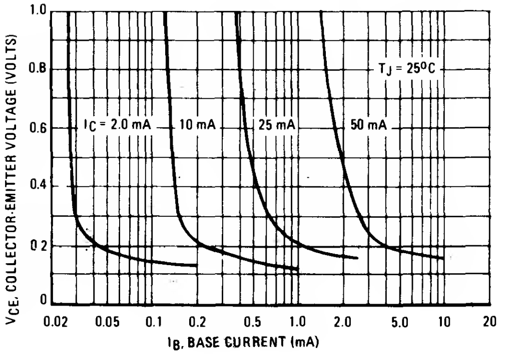
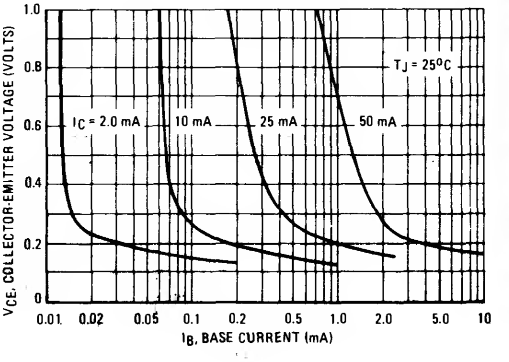
FIGURE 8 – COLLECTOR SATURATION REGION

MD3250



MD3251, MQ3251



MD3467,F
MQ3467

MD3467
CASE 654-07, STYLE 1
MD3467F
CASE 610A-04, STYLE 1
MQ3467
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating		Symbol	Value		Unit
Collector-Emitter Voltage		V_{CEO}	40		Vdc
Collector-Base Voltage		V_{CBO}	40		Vdc
Emitter-Base Voltage		V_{EBO}	5.0		Vdc
Collector Current — Continuous		I_C	1.5		Adc
			One Die	All Die Equal Power	
Total Device Dissipation @ T_A = 25°C		P_D			mW
	MD3467		600	650	
	MD3467F		350	400	
	MQ3467		400	600	
Derate above 25°C					mW/°C
	MD3467		3.42	3.7	
	MD3467F		2.0	2.28	
	MQ3467		2.28	3.42	
Total Device Dissipation @ T_C = 25°C		P_D			Watts
	MD3467		2.1	3.0	
	MD3467F		1.25	2.5	
	MQ3467		1.0	4.0	
Derate above 25°C					mW/°C
	MD3467		12	17.2	
	MD3467F		7.15	14.3	
	MQ3467		5.71	22.8	
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD3467		83.3	58.3	
	MD3467F		140	70	
	MQ3467		175	43.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD3467		292	270	
	MD3467F		500	438	
	MQ3467		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factors					%
	MD3467		85	40	
	MD3467F		75	0	
	MQ3467 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	—	—	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc

MD3467,F, MQ3467

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	—	0.32	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	—	0.95	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	150	220	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	8.5	20	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	22	80	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 30 Vdc, V_{BE} = 2.0 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_d	—	7.0	10	ns
Rise Time		t_r	—	17	30	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_s	—	58	80	ns
Fall Time		t_f	—	14	30	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

FIGURE 1 – DC CURRENT GAIN

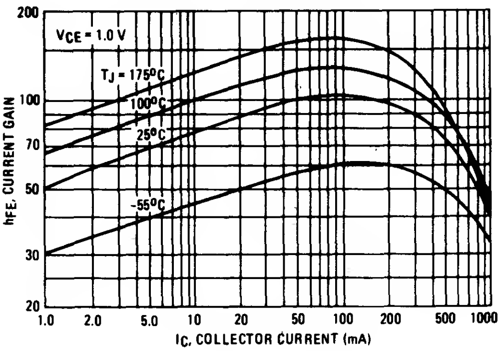


FIGURE 2 – COLLECTOR SATURATION REGION

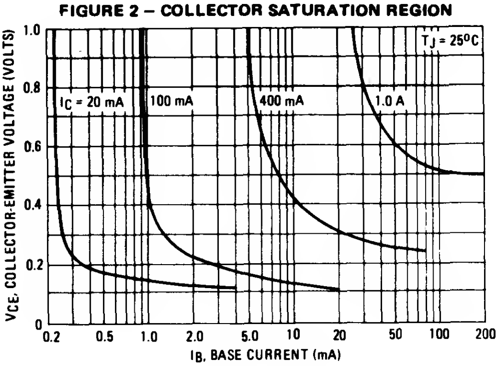


FIGURE 3 – "ON" VOLTAGE

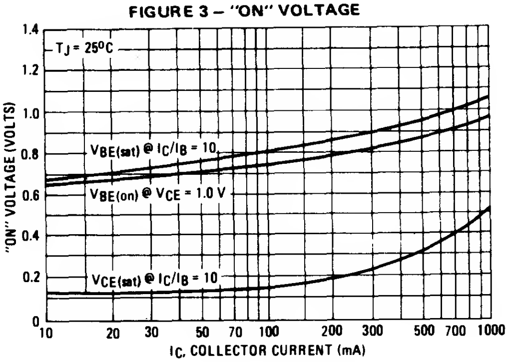


FIGURE 4 – TEMPERATURE COEFFICIENTS

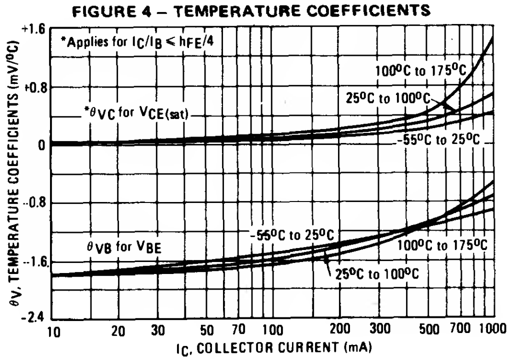


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

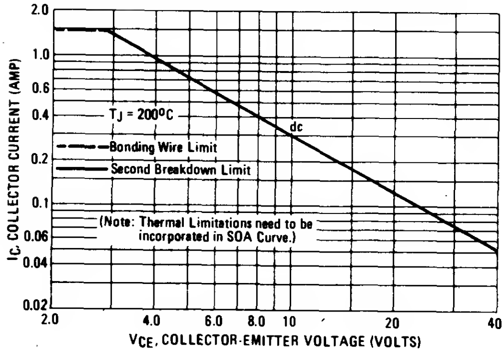


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FIGURE 6 – TURN-ON TIME

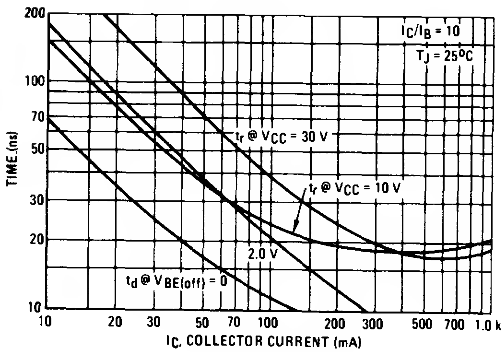


FIGURE 7 – RISE AND FALL TIME

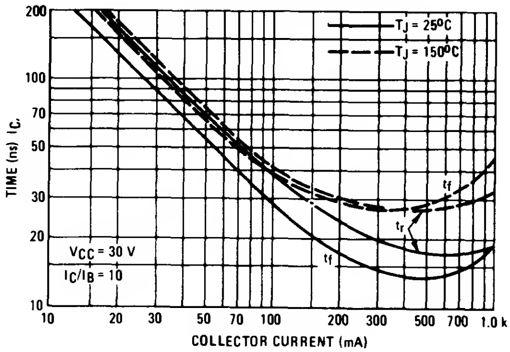


FIGURE 8 – STORAGE TIME

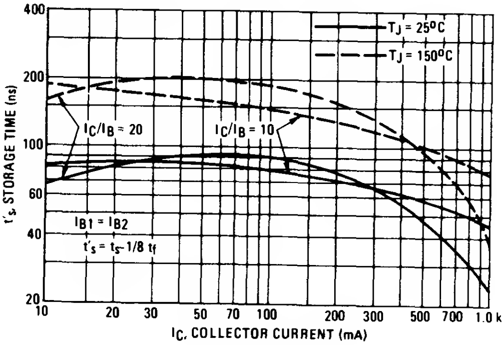


FIGURE 9 – FALL TIME

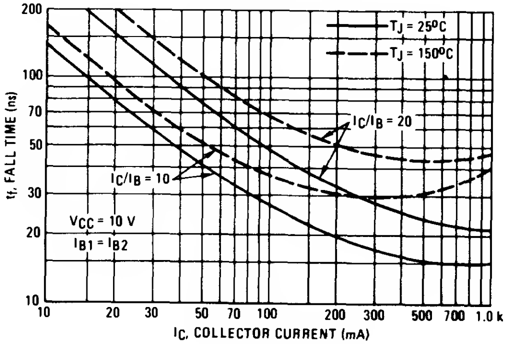


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

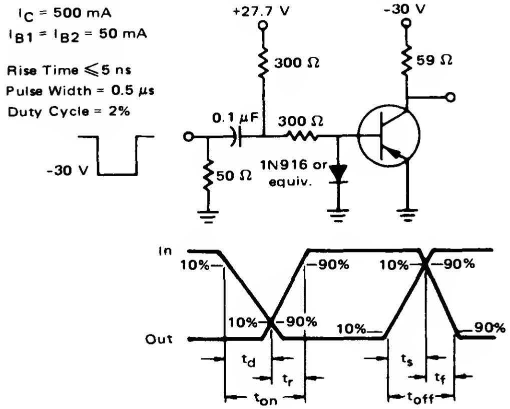
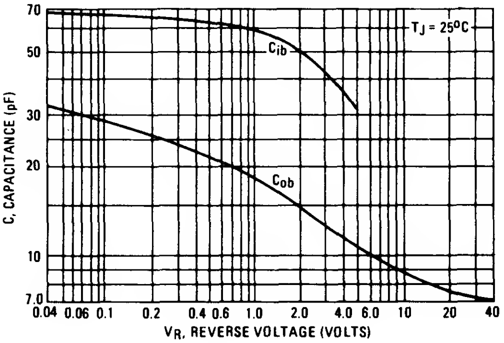


FIGURE 11 – CAPACITANCE



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MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	65		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		One Die	All Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD3725		600	650	
MD3725F		350	400	
MQ3725		400	600	
Derate above 25°C				mW/°C
MD3725		3.42	3.7	
MD3725F		2.0	2.28	
MQ3725		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD3725		2.1	3.0	
MD3725F		1.25	2.5	
MQ3725		1.0	4.0	
Derate above 25°C				mW/°C
MD3725		12	17.2	
MD3725F		7.15	14.3	
MQ3725		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

MD3725,F
MQ3725

MD3725
CASE 654-07, STYLE 1

MD3725F
CASE 610A-04, STYLE 1

MQ3725
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD3725		83.3	58.3	
	MD3725F		140	70	
	MQ3725		175	43.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD3725		292	270	
	MD3725F		500	438	
	MQ3725		433	292	
			Junction to Ambient	Junction to Case	
Coupling Factor					%
	MD3725		85	40	
	MD3725F		75	0	
	MQ3725 (Q1-Q2)		57	0	
	(Q1-Q3, Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0) MD3725F	$V_{(BR)CES}$	65	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 40 Vdc, I_E = 0)		—	0.12	1.7	μAdc
(V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)		—	—	120	μAdc

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ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		50	—	150	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		30	—	—	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.19	0.26	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.30	0.45	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		—	—	0.86	
(I_C = 500 mAdc, I_B = 50 mAdc)		0.80	—	1.2	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	—	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	—	65	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = 3.8 Vdc)	t_{on}	—	20	45	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	50	75	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL DC CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

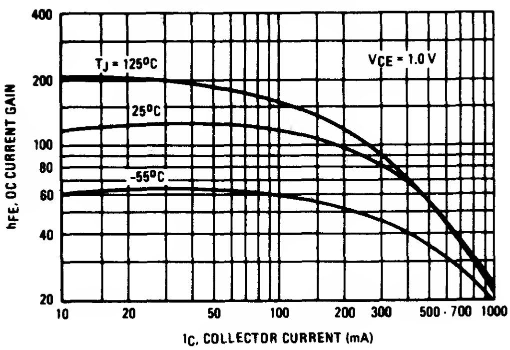


FIGURE 2 – "ON" VOLTAGES

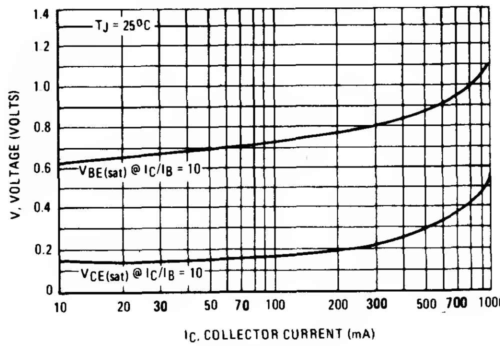


FIGURE 3 – COLLECTOR SATURATION REGION

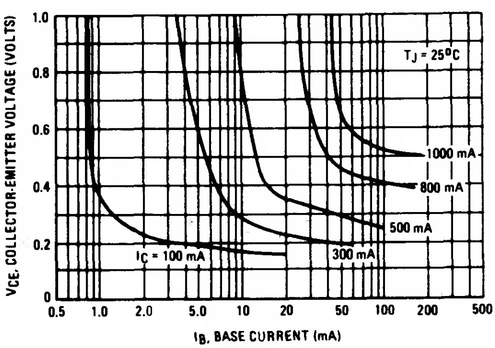
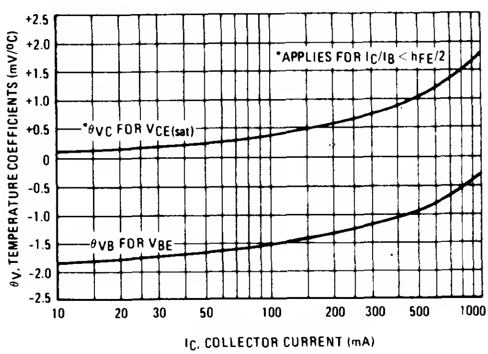


FIGURE 4 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

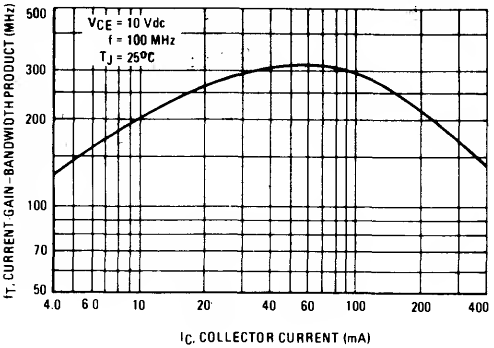


FIGURE 6 – CAPACITANCE

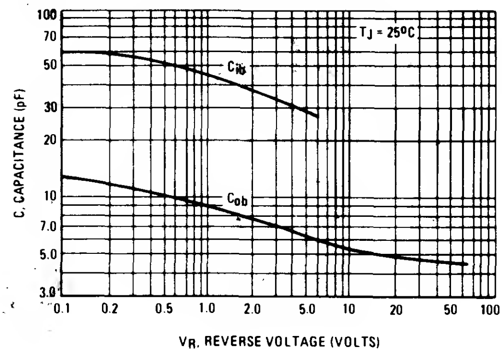


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FIGURE 7 – TURN-ON TIME

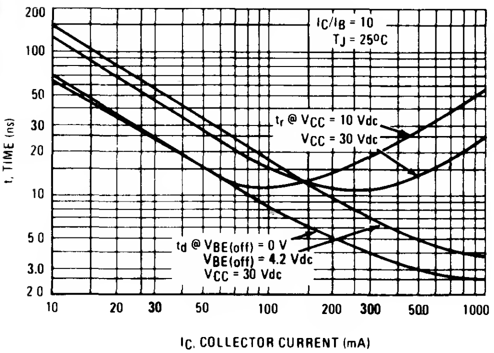


FIGURE 8 – TURN-OFF TIME

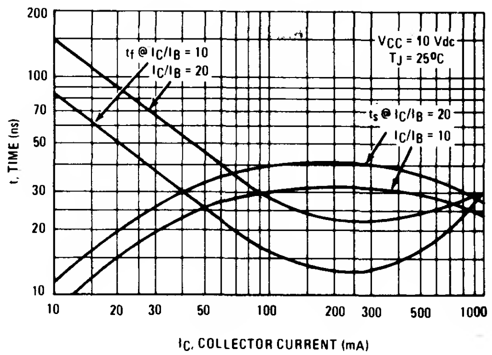


FIGURE 9 – SWITCHING TIME TEST CIRCUIT

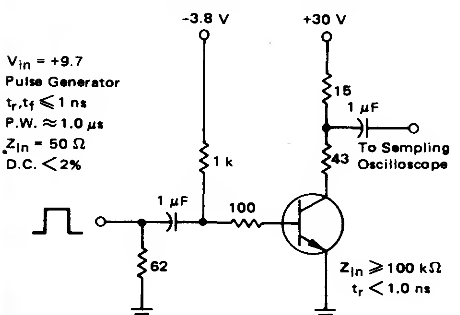
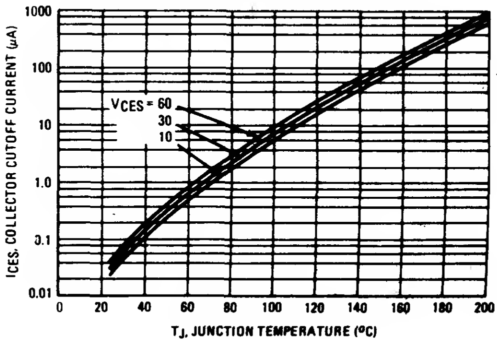


FIGURE 10 – COLLECTOR CUTOFF CURRENT



MD3762,F
MQ3762

MD3762
CASE 654-07, STYLE 1

MD3762F
CASE 610A-04, STYLE 1

MQ3762
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		One Die	All Die Equal Power	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD3762		600	650	
MD3762F		350	400	
MQ3762		400	600	
Derate above 25°C				mW/°C
MD3762		3.42	3.7	
MD3762F		2.0	2.28	
MQ3762		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD3762		2.1	3.0	
MD3762F		1.25	2.5	
MQ3762		1.0	4.0	
Derate above 25°C				mW/°C
MD3762		12	17.2	
MD3762F		7.15	14.3	
MQ3762		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD3762		83.3	58.3	
	MD3762F		140	70	
	MQ3762		175	43.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD3762		292	270	
	MD3762F		500	438	
	MQ3762		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factors					%
	MD3762		85	40	
	MD3762F		75	0	
	MQ3762 (Q1-Q2)		57	0	
	(Q1-Q3, Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 30 Vdc, I_E = 0)		—	—	100	nAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)		—	—	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	40	—	—
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{CE(sat)}$	—	0.52	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{BE(sat)}$	—	1.05	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	150	220	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	8.5	20	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	22	80	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc)	t_d	—	5.0	10	ns
Rise Time		t_r	—	18	30	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_s	—	45	80	ns
Fall Time		t_f	—	18	30	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

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FIGURE 1 – DC CURRENT GAIN

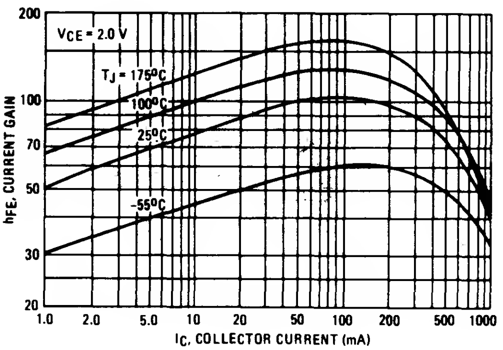


FIGURE 2 – COLLECTOR SATURATION REGION

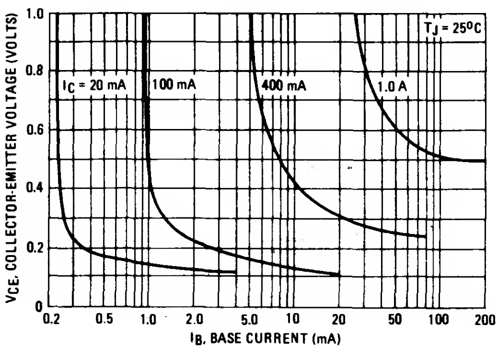


FIGURE 3 – "ON" VOLTAGE

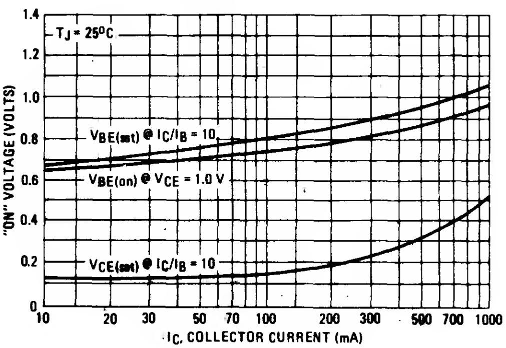


FIGURE 4 – TEMPERATURE COEFFICIENTS

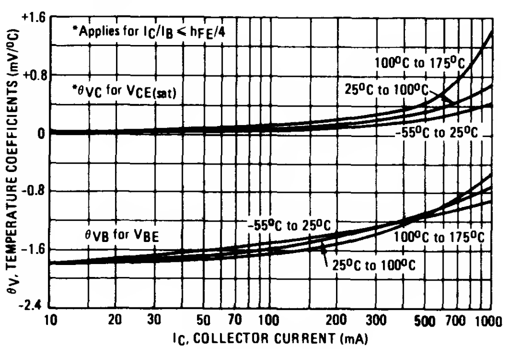


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

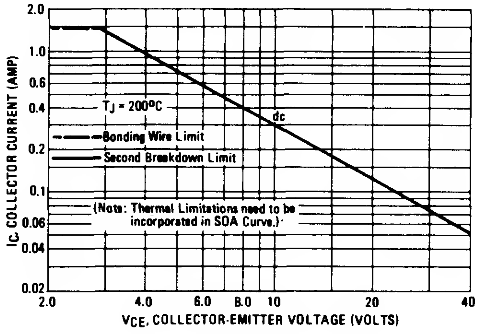


FIGURE 6 – TURN-ON TIME

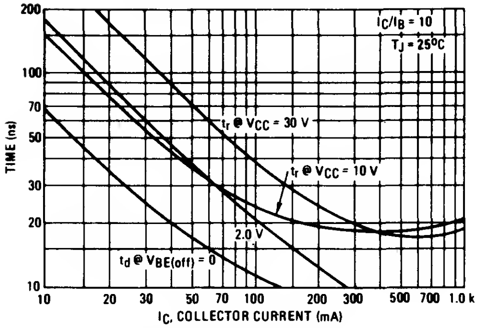


FIGURE 7 – RISE AND FALL TIME

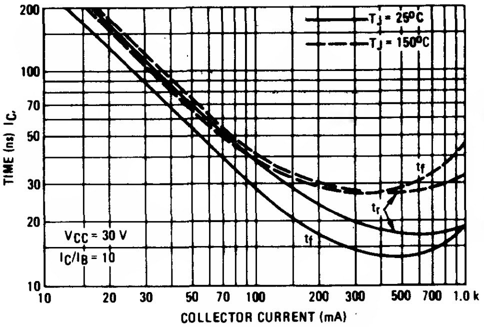


FIGURE 8 – STORAGE TIME

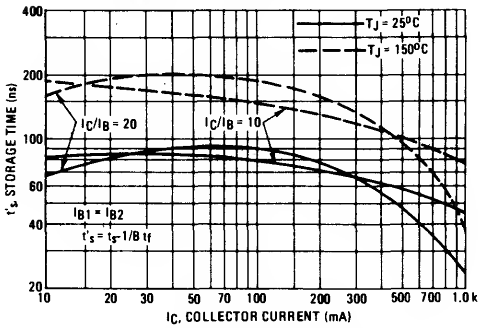


FIGURE 9 – FALL TIME

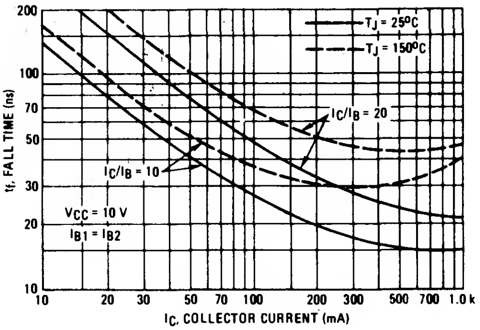


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

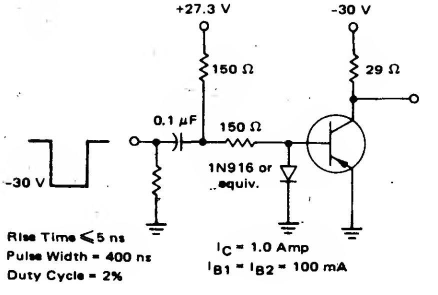
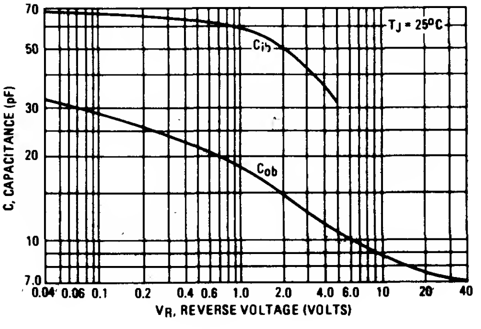


FIGURE 11 – CAPACITANCE



MD5000,A,B

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3307 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	20		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current Continuous	I_C	50		mAdc
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	400 2.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	— —	— —	0.010 1.0	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	20	50	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	600	900	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	—	1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	—	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 60 MHz, R_S = 400 ohms)		NF	—	3.0	6.0	dB
FUNCTIONAL TEST						
Amplifier Power Gain (I_C = 6.0 mAdc, V_{CB} = 12 Vdc, R_G = R_L = 50 ohms, f = 200 MHz)		G_{pe}	15	20	—	dB
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	MD5000 MD5000A MD5000B	h_{FE1}/h_{FE2}	— 0.9 0.8	0.7 — —	— 1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	MD5000 MD5000A MD5000B	$\|V_{BE1}-V_{BE2}\|$	— — —	5.0 — —	— 5.0 10	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = −55 to +125°C)	MD5000 MD5000A MD5000B	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	— — —	10 — —	— 10 20	μV/°C

(1) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD6001,F
MD6002,F
MD6003,F
MQ6001, MQ6002

MD6001
MD6002
MD6003
CASE 654-07, STYLE 5
MD6001F
MD6002F
MD6003F
CASE 610A-04, STYLE 1
MQ6001
MQ6002
CASE 607-04, STYLE 1

COMPLEMENTARY DUAL GENERAL PURPOSE TRANSISTOR
NPN/PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	MD6003 MD6003F	MD6001,F MD6002,F MQ6001,2	Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD6001,2,3		575	625	
MD6001F,2F,3F		350	400	
MQ6001,2		400	600	
Derate above 25°C				
MD6001,2,3		3.29	3.57	mW/°C
MD6001F,2F,3F		2.0	2.28	
MQ6001,2		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD6001,2,3		1.8	2.5	
MD6001F,2F,3F		1.0	2.0	
MQ6001,2		0.9	3.6	
Derate above 25°C				mW/°C
MD6001,2,3		10.3	14.3	
MD6001F,2F,3F		5.71	11.4	
MQ6001,2		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD6001,2,3		97	70	
	MD6001F,2F,3F		175	87.5	
	MQ6001,2		195	48.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD6001,2,3		304	280	
	MD6001F,2F,3F		500	438	
	MQ6001,2		438	292	
			Junction to Ambient	Junction to Class	
Coupling Factor					%
	MD6001,2,3		84	44	
	MD6001F,2F,3F		75	0	
	MQ6001,2 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$				Vdc
(I_C = 10 μAdc, I_E = 0) MD6003,F		50	—	—	
MD6001,F, MD6002,F, MQ6001, MQ6002		60	—	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Base Cutoff Current	I_{BEV}				nAdc
(V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc) MD6003,F		—	—	50	
(V_{CE} = 50 Vdc, V_{EB} = 3.0 Vdc) MD6001,F,2,F, MQ6002,F		—	—	30	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector Cutoff Current		I_{CEV}				
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)	MD6003,F		—	—	30	nAdc
(V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MD6001,F,2,F, MQ6001,2		—	—	20	nAdc
(V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc, T_A = 150°C)	MD6001,F,2,F, MQ6001,2		—	—	30	μAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	MD6003,F	I_{CBO}	—	—	100	nA
ON CHARACTERISTICS(2)						
DC Current Gain		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		20	80	—	
	MD6002,F, MQ6002		35	70	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		25	90	—	
	MD6003,F		40	70	—	
	MQ6002,F, MQ6002		50	100	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		35	70	—	
	MD6002,F, MQ6002		75	110	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		40	—	120	
	MD6003,F		70	110	—	
	MD6002,F, MQ6002		100	200	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		20	—	—	
	All Other Devices		30	90	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		20	80	—	
	MD6002,F, MQ6002		50	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	All Devices		—	0.3	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD6001, MD6002,F, MQ6002,1		—	0.59	1.4	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	All Devices		—	1.02	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD6001, MD6002,F, MQ6001,2		—	1.25	2.0	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

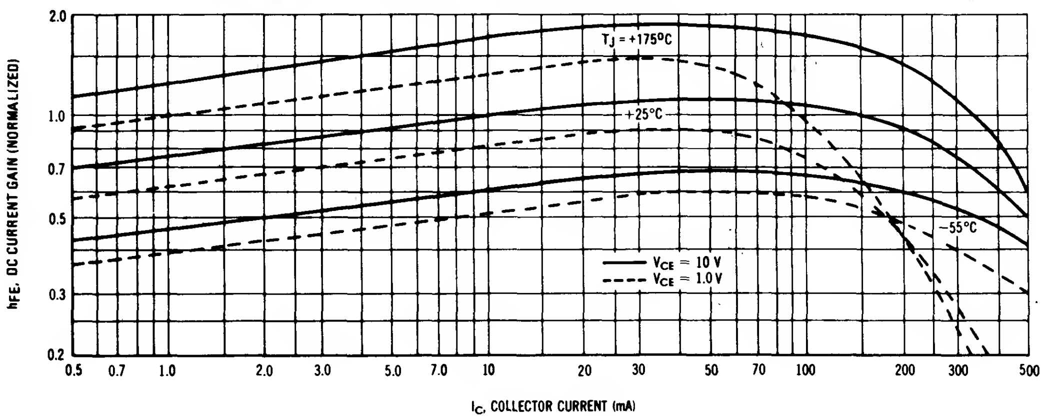


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FIGURE 2 – "ON" VOLTAGES

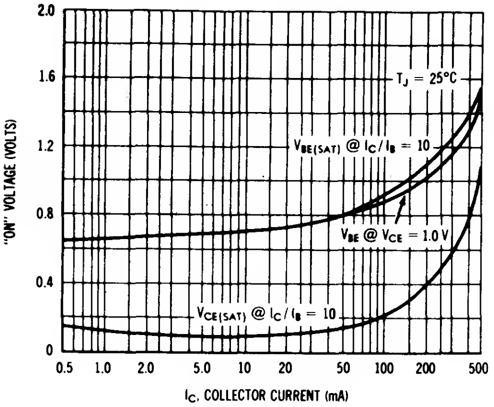
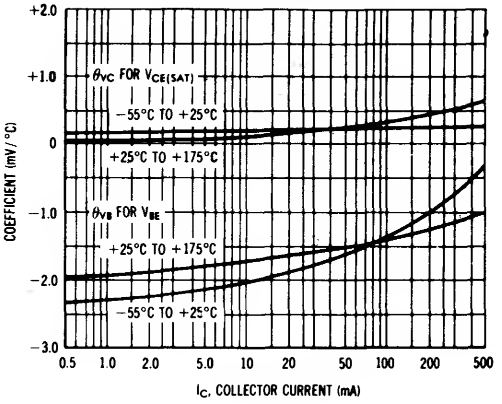


FIGURE 3 – TEMPERATURE COEFFICIENTS



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NOISE FIGURE

$V_{CE} = 10$ V, $T_A = 25°C$

FIGURE 4 – FREQUENCY EFFECTS

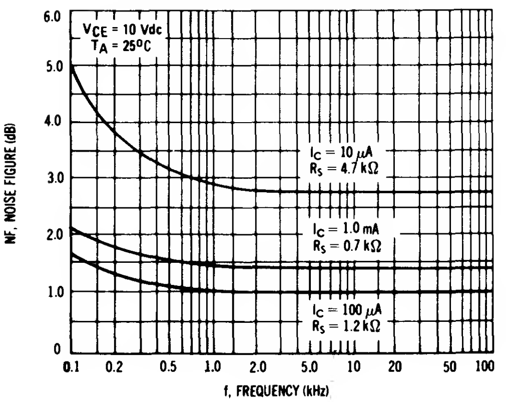

FIGURE 5 – SOURCE RESISTANCE EFFECTS

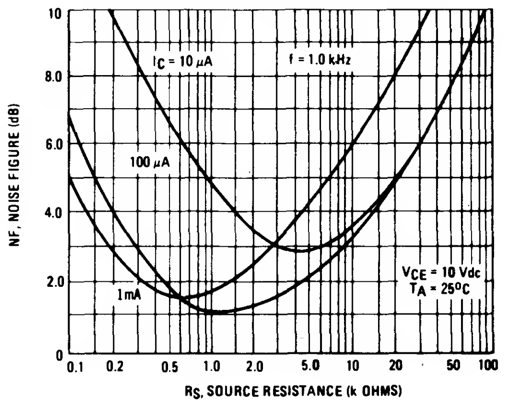

FIGURE 6 – CURRENT-GAIN BANDWIDTH PRODUCT

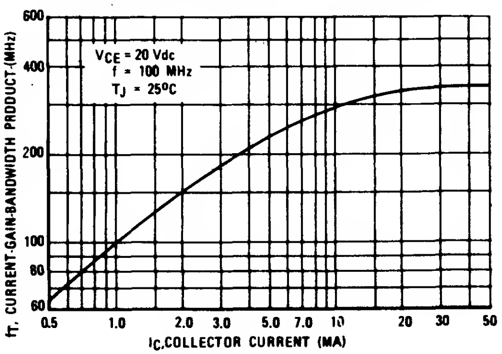

FIGURE 7 – CAPACITANCE

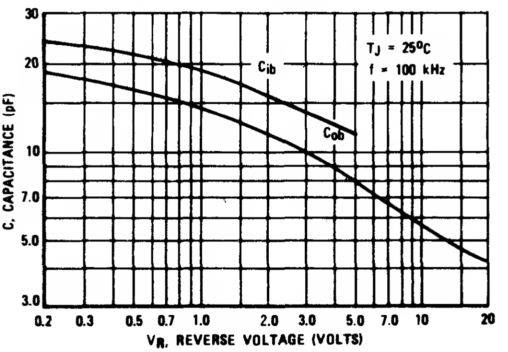

FIGURE 8 — TURN ON TIME

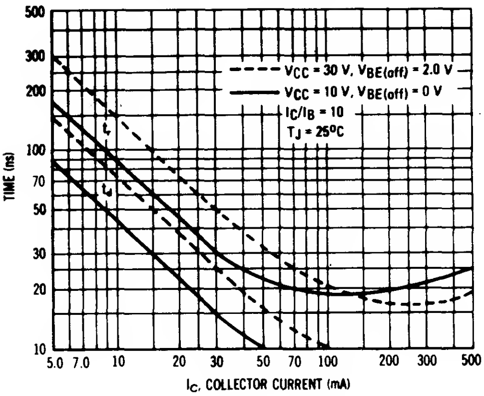

FIGURE 9 — CHARGE DATA

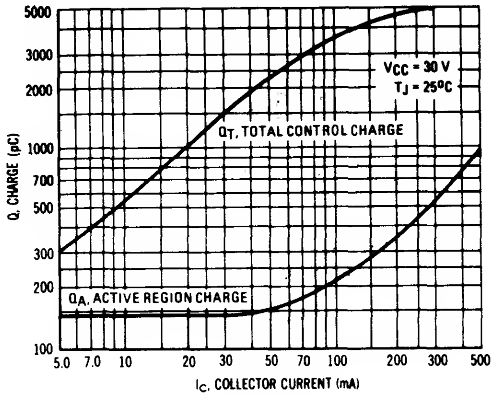

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FIGURE 10 — STORAGE TIME

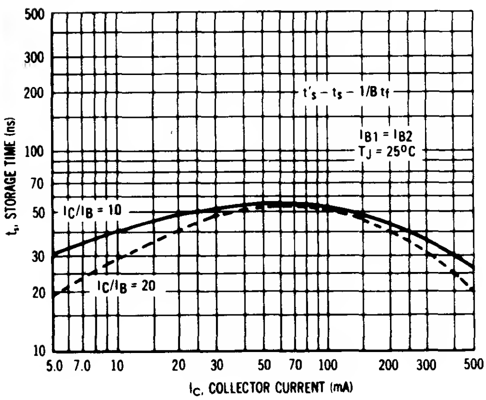


FIGURE 11 — FALL TIME

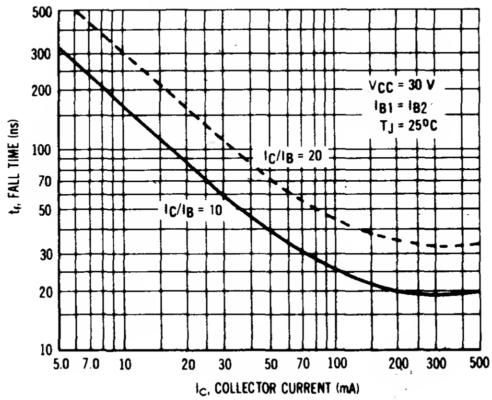


FIGURE 12 — DELAY AND RISE TIME TEST CIRCUIT

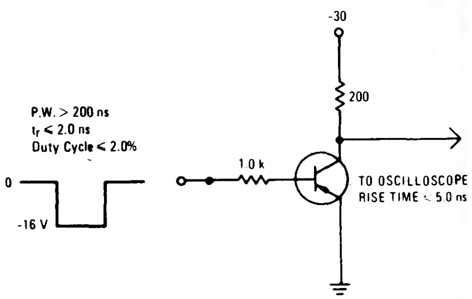
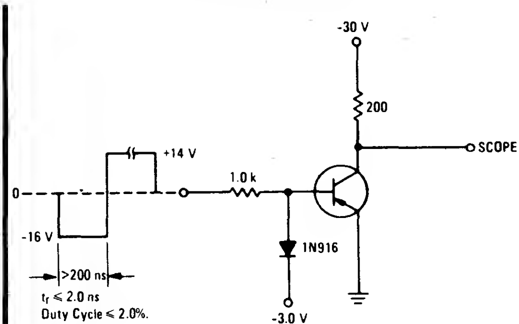


FIGURE 13 — STORAGE AND FALL TIME TEST CIRCUIT



For NPN Test Circuits, Reverse Diode and all Voltage Polarities.

MD7000

CASE 654-07, STYLE 1

DUAL GENERAL PURPOSE TRANSISTOR

NPN SILICON

5

Refer to MD2218 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	Both Die	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factor		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 300 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 40 70 30	 60 80 50	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.2	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	0.95	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	3.5	8.0	pF
Input Capacitance (V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	15	30	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	All Die	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD7001		600	650	
MD7001F		350	400	
MQ7001		400	600	
Derate above 25°C				mW/°C
MD7001		3.42	3.7	
MD7001F		2.0	2.28	
MQ7001		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD7001		2.1	3.8	
MD7001F		1.25	2.5	
MQ7001		1.0	4.0	
Derate above 25°C				mW/°C
MD7001		12	17.2	
MD7001F		7.15	14.3	
MQ7001		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

MD7001,F
MQ7001

MD7001
CASE 654-07, STYLE 1

MD7001F
CASE 610A-04, STYLE 1

MQ7001
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD7001		83.3	58.3	
	MD7001F		140	70	
	MQ7001		175	43.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD7001		292	270	
	MD7001F		500	438	
	MQ7001		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factor					%
	MD7001		85	40	
	MD7001F		75	0	
	MQ7001 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	50	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		70	90	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)		30	60	—	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.25	0.4	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	0.88	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	16	30	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

MD7002,A,B

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2919 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factors		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain(2) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	40 50	130 170	— —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.2	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.8	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 5.0 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	260	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	2.6	6.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	2.3	8.0	pF
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(3) (I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD7002A MD7002B	h_{FE1}/h_{FE2}	0.75 0.85	— —	1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD7002A MD7002B	$\lvert V_{BE1}-V_{BE2}\rvert$	— —	— —	25 15	mVdc

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD7003,A,B,F,AF
MQ7003

MD7003,A,B
CASE 654-07, STYLE 1

MD7003F,AF
CASE 610A-04, STYLE 1

MQ7003
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3810 for curves.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**All Die Equal Power**	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD7003,A,B		550	600	
MD7003F,AF		350	400	
MQ7003		400	600	
Derate above 25°C				mW/°C
MD7003,A,B		3.14	3.42	
MD7003F,AF		2.0	2.28	
MQ7003		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD7003,A,B		1.4	2.0	
MD7003F,AF		0.7	1.4	
MQ7003		0.7	2.8	
Derate above 25°C				mW/°C
MD7003,A,B		8.0	11.4	
MD7003F,AF		4.0	8.0	
MQ7003		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD7003,A,B		125	87.5	
	MD7003F,AF		250	125	
	MQ7003		250	62.6	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD7003,A,B		319	292	
	MD7003F,AF		500	438	
	MQ7003		438	292	
			Junction to Ambient	**Junction to Case**	
Coupling Factor					%
	MD7003,A,B		83	40	
	MD7003F,AF		75	0	
	MQ7003 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(2)	h_{FE}				—
($I_C = 100\ \mu$Adc, $V_{CE} = 10$ Vdc)		40	350	—	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		50	350	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.25	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	3.0	6.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	2.0	8.0	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kohms, f = 10 Hz to 15.7 kHz)		NF	—	2.0	—	dB
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(3) (I_C = 100 μAdc, V_{CE} = 10 Vdc)		h_{FE1}/h_{FE2}				—
	MD7003A,AF		0.75	—	1.0	
	MD7003B		0.85	—	1.0	
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 10 Vdc)		$\lvert V_{BE1}-V_{BE2}\rvert$				mV
	MD7003A,AF		—	—	25	
	MD7003B		—	—	15	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

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MD7007,A,B,F,BF
MQ7007

MD7007,A,B
CASE 654-07, STYLE 1

MD7007F,BF
CASE 610A-04, STYLE 1

MQ7007
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD7007,A,B		575	625	
MD7007F,BF		350	400	
MQ7007		400	600	
Derate above 25°C				mW/°C
MD7007,A,B		3.29	3.57	
MD7007F,BF		2.0	2.28	
MQ7007		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD7007,A,B		1.8	2.5	
MD7007F,BF		1.0	2.0	
MQ7007		0.9	3.6	
Derate above 25°C				mW/°C
MD7007,A,B		10.3	14.3	
MD7007F,BF		5.71	11.4	
MQ7007		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD7007,A,B		97	70	
	MD7007F,BF		175	87.5	
	MQ7007		195	48.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD7007,A,B		304	280	
	MD7007F,BF		500	438	
	MQ7007		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factors					%
	MD7007,A,B		84	44	
	MD7007F,BF		75	0	
	MQ7007 (Q1-Q2)		57	0	
	(Q1-Q2 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		30	110	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		30	130	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		30	75	—	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)		15	25	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	0.38	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	—	0.9	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	600	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	3.8	10	pF
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(3) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		h_{FE1}/h_{FE2}				—
	MD7007A		0.75	—	1.0	
	MD7007B		0.85	—	1.0	
Base-Emitter Voltage Differential (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		$\lvert V_{BE1}-V_{BE2}\rvert$				mVdc
	MD7007A		—	—	20	
	MD7007B		—	—	10	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

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MD7021,F
MQ7021

MD7021
CASE 654-07, STYLE 5

MD7021F
CASE 610A-04, STYLE 1

MQ7021
CASE 607-04, STYLE 1

COMPLEMENTARY GENERAL PURPOSE TRANSISTOR

NPN/PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**All Die Equal Power**	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD7021		550	600	
MD7021F		350	400	
MQ7021		400	600	
Derate above 25°C				mW/°C
MD7021		3.14	3.42	
MD7021F		2.0	2.28	
MQ7021		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD7021		1.4	2.0	
MD7021F		0.7	1.4	
MQ7021		0.7	2.8	
Derate above 25°C				mW/°C
MD7021		8.0	11.4	
MD7021F		4.0	8.0	
MQ7021		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD7021		125	87.5	
	MD7021F		250	125	
	MQ7021		250	62.6	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD7021		319	292	
	MD7021F		500	438	
	MQ7021		438	292	
			Junction to Ambient	**Junction to Case**	
Coupling Factor					%
	MD7021		83	40	
	MD7021F		75	0	
	MQ7021 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		40	65	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	70	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)(2)	$V_{CE(sat)}$	—	—	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	—	6.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	—	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 Adc)	t_{on}	—	28	—	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	72	—	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MD8001
MD8002
MD8003

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2920 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage MD8001 MD8002 MD8003	V_{CEO}	40 50 60		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	**Both Die Equal Power**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die Max	Both Die Equal Power Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
		Junction to Ambient	**Junction to Case**	
Coupling Factor		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	MD8001 MD8002 MD8003	$V_{(BR)CEO}$	40 50 60	— — —	— — —	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	100	200	—	—
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	—	260	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	2.6	—	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	2.3	—	pF
MATCHING CHARACTERISTICS						
Base-Emitter Voltage Differential (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		$\|V_{BE1}-V_{BE2}\|$	—	—	15	mVdc

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ918

CASE 632-02, STYLE 1
TO-116

QUAD AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD918 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.65 3.72	1.9 10.88	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.3 7.43	4.6 26.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	 — 20 —	 110 80 50	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.11	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.84	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	600	850	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	0.75	2.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	1.4	2.5	pF
Noise Figure ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 400$ Ohms, f = 60 MHz)	NF	—	4.0	6.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ2221
MHQ2222
MPQ2221*
MPQ2222*

MHQ2221
MHQ2222
CASE 632-02, STYLE 1
TO-116

MPQ2221
MPQ2222
CASE 646, STYLE 1

QUAD
GENERAL PURPOSE TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ $T_A = 25°C$	P_D	0.65	1.9	Watts
Derate above 25°C MHQ2221, MHQ2222		3.72	10.88	mW/°C
MPQ2221, MPQ2222		5.2	15.2	
Operating and Storage Junction Temperature Range MHQ2221,22	T_J, T_{stg}	−65 to +200		°C
MPQ2221,22		−55 to +150		

Refer to MD2218 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	MHQ2221, MPQ2221		35	—	—	
	MHQ2222, MPQ2222		75	—	—	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	MHQ2221, MPQ2221		40	—	—	
	MHQ2222, MPQ2222		100	—	—	
($I_C = 300$ mAdc, $V_{CE} = 10$ Vdc)	MHQ2221, MPQ2221		20	—	—	
	MHQ2222, MPQ2222		30	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
($I_C = 150$ mAdc, $I_B = 15$ mAdc)			—	—	0.4	
($I_C = 300$ mAdc, $I_B = 30$ mAdc)			—	—	1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
($I_C = 150$ mAdc, $I_B = 15$ mAdc)			—	—	1.3	
($I_C = 300$ mAdc, $I_B = 30$ mAdc)			—	—	2.6	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	200	350	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	4.5	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	17	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time ($V_{CC} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)		t_{on}	—	25	—	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)		t_{off}	—	250	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
*MPQ2221A and MPQ2222A also available.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

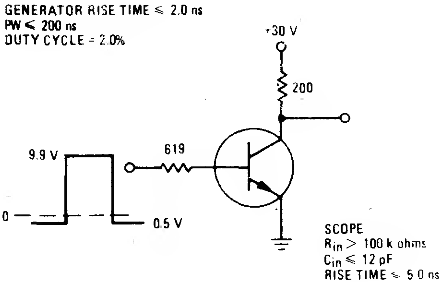
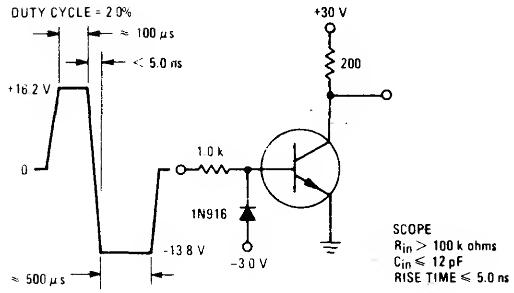


FIGURE 2 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



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MHQ2369
MPQ2369

MHQ2369
CASE 632-02, STYLE 1

MPQ2369
CASE 646-05, STYLE 1
TO-116

QUAD
SWITCHING TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C Derate above 25°C MHQ2369 MPQ2369	P_D	 0.5 2.86 5.0	 1.5 8.58 15	 Watts mW/°C
Operating and Storage Junction Temperature Range MHQ2369 MPQ2369	T_J, T_{stg}	 −65 to +200 −55 to +125		°C

Refer to MD2369 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

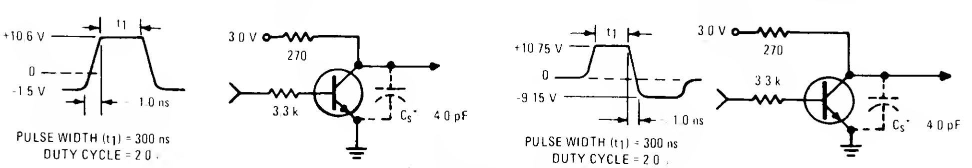
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.4	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	40 20	— —	— —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	450	550	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	2.5	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	3.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 3.0 Vdc, V_{BE} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	9.0	—	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	—	15	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – t_{on} CIRCUIT

FIGURE 2 – t_{off} CIRCUIT



*Total Shunt Capacitance of test jig and connectors

MHQ2483
MHQ2484

CASE 632-02, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2919 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 3.42	1.8 10.3	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.85	4.2 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 45$ Vdc, $I_E = 0$)		I_{CBO}	—	—	20	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	MHQ2483 MHQ2484		100 200	— —	— —	
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	MHQ2483 MHQ2484		150 300	— —	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	MHQ2483 MHQ2484		150 300	— —	— —	
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	— —	0.13 0.15	0.35 0.5	Vdc
Base-Emitter On Voltage ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	— —	0.58 0.70	0.7 0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 500\ \mu$Adc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	50	100	—	MHz
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	4.0	8.0	pF
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{cb}	—	1.8	6.0	pF
Noise Figure ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kohms, f = 10 Hz to 15.7 kHz, BW = 10 kHz)	MHQ2483 MHQ2484	NF	— —	3.0 2.0	— —	dB

MHQ2906
MHQ2907
MPQ2906*
MPQ2907*

MHQ2906, MHQ2907
CASE 632-02, STYLE 1

MPQ2906
MPQ2907
CASE 646-05, STYLE 1
TO-116

QUAD
GENERAL PURPOSE
TRANSISTOR

PNP SILICON

Refer to MD2904 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ T_A = 25°C	P_D	0.65	1.9	Watts
Derate above 25°C MHQ2906, MHQ2907		3.72	10.88	mW/°C
MPQ29006, MPQ2907		6.5	19	
Operating and Storage Junction Temperature Range MHQ2906,07	T_J, T_{stg}	−65 to +200		°C
MPQ2906,07		−55 to +125		

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{CB} = 3.0 Vdc, I_E = 0)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MHQ2906, MPQ2906		35	—	—	
	MHQ2907, MPQ2907		75	—	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MHQ2906, MPQ2906		40	—	—	
	MHQ2907, MPQ2907		100	—	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MHQ2906, MPQ2906		30	—	—	
	MHQ2907, MPQ2907		50	—	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	1.6	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	2.6	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	350	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	6.0	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	20	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)		t_{on}	—	30	—	ns
Turn-Off Time (V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		t_{off}	—	100	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.
*MPQ2906A and MPQ2907A also available.

FIGURE 1 – DELAY AND RISE TIME TEST CIRCUIT

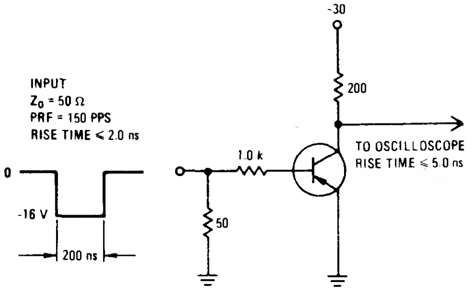
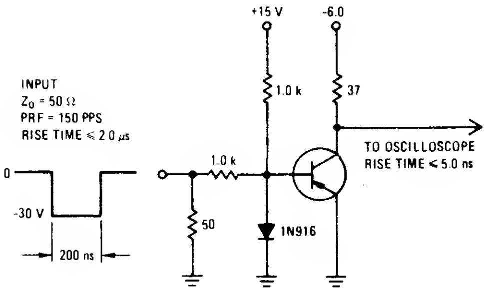


FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT



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MHQ3467

CASE 632-02, STYLE 1
TO-116

QUAD
MEMORY DRIVER TRANSISTOR

PNP SILICON

5

Refer to MD3467 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	**Total Device**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.9 5.14	2.7 15.4	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3	6.3 36	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	200	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	200	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage(1) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{CE(sat)}$	—	0.23	0.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{BE(sat)}$	—	0.9	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	125	190	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	10	25	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	55	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_C = 500$ mAdc, $I_{B1} = 50$ mAdc)	t_{on}	—	—	40	ns
Turn-Off Time ($I_C = 500$ mAdc, $I_{B1} = I_{B2} = 50$ mAdc)	t_{off}	—	—	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ3546
MPQ3546

MHQ3546
CASE 632-02, STYLE 1
TO-116

MPQ3546
CASE 646-05, STYLE 1

QUAD SWITCHING TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating		Symbol	Value		Unit
Collector-Emitter Voltage		V_{CEO}	12		Vdc
Collector-Base Voltage		V_{CBO}	15		Vdc
Emitter-Base Voltage		V_{EBO}	4.5		Vdc
Collector Current — Continuous		I_C	200		mAdc
			Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C		P_D	0.5	1.5	Watts
Derate above 25°C	MHQ3546		2.86	8.58	mW/°C
	MPQ3546		4.0	12	
Operating and Storage Junction Temperature Range	MHQ3546	T_J, T_{stg}	−65 to +200		°C
	MPQ3546		−55 to +150		

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	µAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.1	µAdc
ON CHARACTERISTICS					
DC Current Gain(1)	h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		30	—	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		15	—	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	1000	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	2.0	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 2.0 Vdc, $V_{BE(off)}$ = 3.0 Vdc, I_C = 30 mAdc, I_{B1} = 1.5 mAdc)	t_{on}	—	15	—	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc)	t_{off}	—	25	—	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

MHQ3798
MHQ3799

CASE 632-02, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3810 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	MHQ3798	MHQ3799	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.86	1.5 8.58	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 5.71	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MHQ3798 MHQ3799	$V_{(BR)CEO}$	40 60	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)		I_{CBO}	—	—	10	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	MHQ3798 MHQ3799	h_{FE}	100 225	— —	— —	—
($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	MHQ3798 MHQ3799		150 300	— —	— —	
($I_C = 500\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	MHQ3798 MHQ3799		150 300	— —	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	MHQ3798 MHQ3799		125 250	— —	— —	
Collector-Emitter Saturation Voltage ($I_C = 100\ \mu$Adc, $I_B = 10\ \mu$Adc) ($I_C = 1.0$ mAdc, $I_B = 100\ \mu$Adc)		$V_{CE(sat)}$	— —	— —	0.2 0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 100\ \mu$Adc, $I_B = 10\ \mu$Adc) ($I_C = 1.0$ mAdc, $I_B = 100\ \mu$Adc)		$V_{BE(sat)}$	— —	— —	0.7 0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	—	130	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	2.3	—	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	5.5	—	pF
Noise Figure ($I_C = 100\ \mu$Adc, $V_{CE} = 10$ Vdc, $R_S = 3.0$ kohms, f = 10 Hz to 15.7 kHz)	MHQ3798 MHQ3799	NF	— —	2.5 1.5	— —	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	MHQ4001A	MHQ4002A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Collector-Base Voltage	V_{CBO}	60	70	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	750 4.3	2500 14.3	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.86	4.0 22.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +200		°C

MHQ4001A
MHQ4002A

CASE 632-02, STYLE 1
TO-116

QUAD
MEMORY DRIVER TRANSISTOR

NPN SILICON

Refer to MD3725 for graphs.

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MHQ4001A MHQ4002A	$V_{(BR)CEO}$	40 45	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	MHQ4001A MHQ4002A	$V_{(BR)CES}$	60 70	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MHQ4001A MHQ4002A	$V_{(BR)CBO}$	60 70	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	500	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain	(I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	50 30 20	100 60 45	250 — —	—
Collector-Emitter Saturation Voltage	(I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	— — —	0.14 0.23 0.36	0.26 0.52 0.95	Vdc
Base-Emitter Saturation Voltage	(I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	— 0.8 —	0.75 0.88 1.0	0.86 1.1 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	200	275	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	5.0	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	55	70	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, I_C = 0.5 Adc, V_{BE} = 3.8 Vdc, I_{B1} = 50 mAdc)		t_{on}	—	30	40	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 0.5 Adc, I_{B1} = I_{B2} = 50 mAdc)		t_{off}	—	60	75	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ4013
MHQ4014

CASE 632-02, STYLE 1
TO-116

QUAD
MEMORY DRIVER TRANSISTOR

NPN SILICON

Refer to MD3725 for graphs.

5

MAXIMUM RATINGS

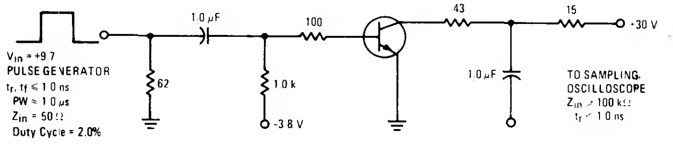
Rating	Symbol	MHQ4013	MHQ4014	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Collector-Base Voltage	V_{CBO}	60	70	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	750 4.3	2500 14.3	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.86	4.0 22.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MHQ4013 MHQ4014	$V_{(BR)CEO}$	40 45	— —	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10\ \mu$Adc, $V_{BE} = 0$)	MHQ4013 MHQ4014	$V_{(BR)CES}$	60 70	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	MHQ4013 MHQ4014	$V_{(BR)CBO}$	60 70	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)		I_{CBO}	—	—	500	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc)		h_{FE}	60 35 25	100 65 50	250 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	— — —	0.14 0.23 0.36	0.26 0.52 0.95	Vdc
Base-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc)		$V_{BE(sat)}$	— 0.8 —	0.75 0.88 1.0	0.86 1.1 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	200	275	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	5.0	10	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	50	70	pF
SWITCHING CHARACTERISTICS						
Turn-On Time ($V_{CC} = 30$ Vdc, $I_C = 0.5$ Adc, $V_{BE(off)} = 3.8$ Vdc, $I_{B1} = 50$ mAdc)		t_{on}	—	20	35	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 0.5$ Adc, $I_{B1} = I_{B2} = 50$ mAdc)		t_{off}	—	50	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



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MHQ6001
MHQ6002

CASE 632-02, TYPE 1
TO-116

QUAD
COMPLEMENTARY TRANSISTOR

NPN/PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	 0.65 3.72	 1.9 10.88	 Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	 1.3 7.43	 4.6 26.3	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)	I_{CBO}	—	—	20	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	30	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)	h_{FE}				—
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) MHQ6001		25	—	—	
MHQ6002		50	—	—	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) MHQ6001		35	—	—	
MHQ6002		75	—	—	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) MHQ6001		40	—	—	
MHQ6002		100	—	—	
($I_C = 300$ mAdc, $V_{CE} = 10$ Vdc) MHQ6001		20	—		
MHQ6002		30	—		
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)	$V_{CE(sat)}$	— —	— —	0.4 1.4	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)	$V_{BE(sat)}$	— —	— —	1.3 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 kHz)	f_T	—	400	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz) NPN PNP	C_{obo}	— —	6.0 4.5	— —	pF
Input Capacitance ($V_{BE} = 2.0$ Vdc, $I_C = 0$, f = 100 kHz) NPN PNP	C_{ibo}	— —	20 17	— —	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30$ Vdc, $V_{BE} = 0.5$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)	t_{on}	—	30	—	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)	t_{off}	— —	225 —	— —	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ6100,A

CASE 632-02, TYPE 2
TO-116

QUAD COMPLEMENTARY PAIR TRANSISTOR

NPN/PNP SILICON

Refer to 2N2919 for NPN graphs.
Refer to 2N3810 for PNP graphs.

5

MAXIMUM RATINGS

Rating	Symbol	MHQ6100	MHQ6100A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.86	1.5 8.58	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 5.71	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MHQ6100 MHQ6100A	$V_{(BR)CEO}$	40 45	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A	h_{FE}	50 100	— —	— —	—
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		75 150	— —	— —	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		75 150	— —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		60 125	— —	— —	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{BE(sat)}$	—	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	NPN PNP	f_T	— —	175 130	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	NPN PNP	C_{obo}	— —	4.5 2.3	— —	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	NPN PNP	C_{ibo}	— —	6.0 5.5	— —	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ918

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

NPN SILICON

5

Refer to MD918 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	6.7 0.825	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 134	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	— 20 —	110 80 50	— — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.11	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.84	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	850	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	0.75	1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	1.1	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_G = 400 Ohms, f = 60 MHz)	NF	—	4.0	6.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	650 5.18	1250 10	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

MPQ1000

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD2218 for graphs.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)	Each Die Effective, 4 Die	125 41.6	193 100	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	30 2.0	60 24	% %

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	 50 50 40	 — — —	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	175	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	—	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	—	30	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ1500

CASE 646-05, STYLE 1
TO-116

QUAD

PNP SILICON

5

Refer to MD2904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.65 5.18	1.25 8.0	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)			°C/W
Each Die	125	193	
Effective, 4 Die	41.6	100	
Coupling Factor			%
Q1-Q4 or Q2-Q3	30	60	
Q1-Q2 or Q3-Q4	2.0	24	

(1) Junction to ambient data applies for typical printed circuit board mounting.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	100	—	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)		50	120	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		40	80	—	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.22	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	0.89	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	150	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.5	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	17	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ2221, MPQ2222

For Specifications, See MHQ2221 Data.

MPQ2369

For Specifications, See MHQ2369 Data.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	134	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

MPQ2483
MPQ2484

CASE 646-05, STYLE 1
TO-116

QUAD AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2919 for graphs.

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	—	—	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		100	—	—	
	MPQ2484		200	—	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		150	—	—	
	MPQ2484		300	—	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		150	—	—	
	MPQ2484		300	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			—	0.13	0.35	
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	0.15	0.5	
Base-Emitter Saturation Voltage(2)		$V_{BE(sat)}$				Vdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			—	0.58	0.7	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			—	0.70	0.8	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	100	—	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	4.0	8.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	—	1.8	6.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms,	MPQ2483	NF	—	3.0	—	dB
f = 10 Hz to 15.7 kHz, BW = 10 kHz)	MPQ2484		—	2.0	—	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

MPQ2906, MPQ2907

For Specifications, See MHQ2906 Data.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	12		Vdc
Collector-Base Voltage	V_{CBO}	25		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	650 5.2	1250 10	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

MPQ3303

CASE 646-05, STYLE 1
TO-116

QUAD SWITCHING TRANSISTOR

NPN SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	125 41.6	193* 100*	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	30 2.0	60 25	% %

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 0.5 Vdc) (I_C = 300 mAdc, V_{CE} = 0.5 Vdc)	h_{FE}	 30 40	 45 55	 — 200	—
Collector-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	 — —	 0.22 0.52	 0.33 0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$	 — —	 0.87 1.04	 1.1 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	400	500	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	5.0	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	22	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 12 Vdc, I_C = 1.0 Adc, $V_{BE(off)}$ = 4.0 Vdc, I_{B1} = 100 mAdc)	t_{on}	—	12	15	ns
Turn-Off Time (V_{CC} = 12 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_{off}	—	18	25	ns

MPQ3467

CASE 646-05, STYLE 1
TO-116

QUAD
MEMORY DRIVER TRANSISTOR

PNP SILICON

Refer to MD3467 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	650 5.2	1500 12	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.25 10	3.2 25.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 2 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		$R_{\theta JC}$ Junction to Case	$R_{\theta JA}$ Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	100 39	193 83.2	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	45 5.0	55 10	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	200	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	200	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage(2) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	0.23	0.5	Vdc
Base-Emitter Saturation Voltage(2) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	—	0.90	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	190	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	10	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	55	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	—	—	40	ns
Turn-Off Time (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	—	90	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ3546 For Specifications, See MHQ3546 Data.

MPQ3725,A

CASE 646-05, STYLE 1
TO-116

QUAD
CORE DRIVER TRANSISTOR

NPN SILICON

Refer to MD3725 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	MPQ3725	MPQ3725A	Unit
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		One Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max		Unit
		One Transistor	Effective For Four Transistors	
Thermal Resistance, Junction to Ambient(1)	$R_{\theta JA}$	125	50	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

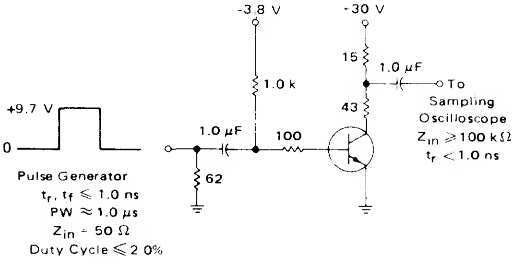
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	MPQ3725 MPQ3725A	$V_{(BR)CEO}$	40 50	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	MPQ3725 MPQ3725A	$V_{(BR)CES}$	60 70	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	—	—	0.5	μAdc
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MPQ3725 MPQ3725A	h_{FE}	35 40	75 80	200 —	—
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	MPQ3725 MPQ3725A		25 30	45 50	— —	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	—	0.32	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	0.8	0.9	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPQ3725 MPQ3725A	f_T	250 200	275 250	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	5.1	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	62	80	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = 3.8 Vdc)	t_{on}	—	20	35	ns
Turn-Off Time (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	50	60	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	750 5.98	1700 13.6	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.25 10	3.2 25.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)	Each Die Effective, 4 Die	100 39	167 73.5	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	46 5.0	56 10	% %

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MPQ3762

CASE 646-05, STYLE 1
TO-116

QUAD
MEMORY DRIVER TRANSISTOR

PNP SILICON

Refer to MD3467 for graphs.

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	 35 30 20	 70 65 35	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	 — —	 0.3 0.6	 0.55 0.9	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	 — —	 0.9 1.0	 1.25 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	275	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	9.0	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	55	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc, $V_{BE(off)}$ = 2.0 Vdc)	t_{on}	—	—	50	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_{off}	—	—	120	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON

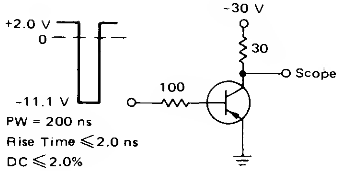
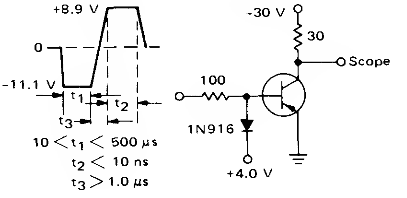


FIGURE 2 – TURN-OFF



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MAXIMUM RATINGS

Rating	Symbol	MPQ3798	MPQ3799	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	 0.5 4.0	 0.9 7.2	 Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 0.825 6.7	 2.4 19.2	 Watts m/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second breakdown occurs at power levels greater than 3 times the power dissipation rating.

MPQ3798
MPQ3799

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3810 for graphs.

5

THERMAL CHARACTERISTICS

Characteristic		$R_{\theta JC}$ Junction to Case	$R_{\theta JA}$ Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	 MPQ3798 MPQ3799	$V_{(BR)CEO}$	 40 60	 — —	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	 MPQ3798 MPQ3799	h_{FE}	 100 225	 — —	— — —	—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MPQ3798 MPQ3799		150 300	— —	— —	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MPQ3798 MPQ3799		150 300	— —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ3798 MPQ3799		125 250	— —	— —	
Collector-Emitter Saturation Voltage (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$	 — —	 0.12 0.07	 0.2 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	 — —	 0.62 0.68	 0.7 0.8	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	60	250	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	2.1	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	5.5	8.0	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kohms, f = 10 Hz to 15.7 kHz)	MPQ3798	NF	—	2.5	—	dB
	MPQ3799		—	1.5	—	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

MPQ3904

CASE 646-05, STYLE 1
TO-116

QUAD AMPLIFIER/SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N3904 for graphs.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{BE} = 40 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 50 75	 90 160 200	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.1	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	300	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	2.0	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	4.0	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 10 mAdc, V_{BE} = 0.5 Vdc, I_{B1} = 1.0 mAdc)	t_{on}	—	37	—	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_{off}	—	136	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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MPQ3906

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER/SWITCH TRANSISTOR

PNP SILICON

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Refer to 2N3906 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	 40 60 75	 160 180 200	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.1	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	250	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	3.3	4.5	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	4.8	10	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_C = 10$ mAdc, $V_{BE(off)} = 0.5$ Vdc, $I_{B1} = 1.0$ mAdc)	t_{on}	—	43	—	ns
Turn-Off Time ($I_C = 10$ mAdc, $I_{B1} = I_{B2} = 1.0$ mAdc)	t_{off}	—	155	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DELAY AND RISE TIME
EQUIVALENT TEST CIRCUIT

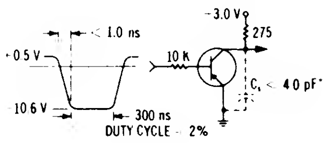
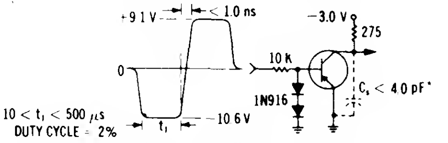


FIGURE 2 – STORAGE AND FALL TIME
EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

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MPQ6001
MPQ6002
TYPE 1
MPQ6501
MPQ6502
TYPE 2

CASE 646-05

QUAD COMPLEMENTARY PAIR TRANSISTOR

PNP/NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) MPQ6001, MPQ6002, MPQ6501, MPQ6502	P_D	0.65	1.25	Watts
Derate above 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502		5.18	10	mW/°C
Total Device Dissipation @ T_C = 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502	P_D	1.0	3.0	Watts
Derate above 25°C MPQ6001, MPQ6002, MPQ6501, MPQ6502		8.0	24	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance		125	193	°C/W
Each Die	MPQ6001, MPQ6002, MPQ6501, MPQ6502			
Effective, 4 Die	MPQ6001, MPQ6002, MPQ6501, MPQ6502	41.6	100	
Coupling Factors		30	60	%
	MPQ6001, MPQ6002	30	60	
Q1-Q4 or Q2-Q3	MPQ6501, MPQ6502	30	60	
		30	60	
	MPQ6001, MPQ6002			
Q1-Q2 or Q3-Q4	MPQ6501, MPQ6502	20	24	
		20	24	
		20	24	
		2.0	24	

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	30	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	30	nAdc
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		25	—	—	
	MPQ6002, MPQ6502		50	—	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		35	—	—	
	MPQ6002, MPQ6502		75	—	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		40	—	—	
	MPQ6002, MPQ6502		100	—	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		20	—	—	
	MPQ6002, MPQ6502		30	—	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage(2)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	1.4	
Base-Emitter Saturation Voltage(2)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	2.0	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	350	—	MHz
Output Capacitance		C_{obo}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	PNP		—	6.0	8.0	
	NPN		—	4.5	8.0	
Input Capacitance		C_{ibo}				pF
(V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)	PNP		—	20	30	
	NPN		—	17	30	
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, V_{BE} = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc, Figure 1)		t_{on}	—	30	—	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		t_{off}	—	225	—	ns

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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NPN DATA

FIGURE 1 — NORMALIZED DC CURRENT GAIN

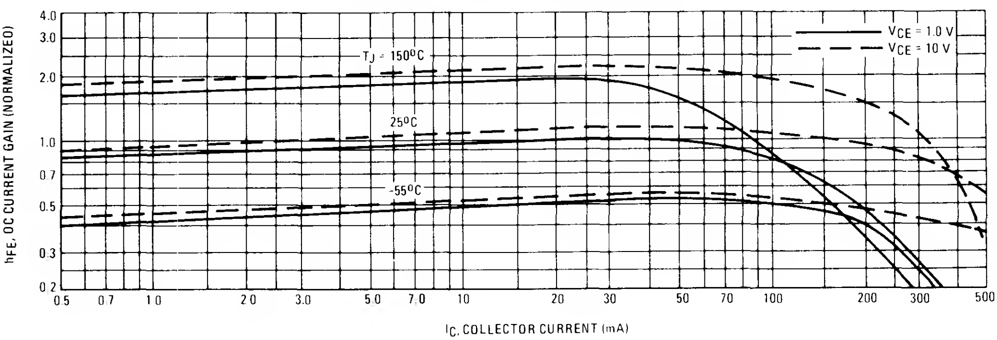


FIGURE 2 — "ON" VOLTAGES

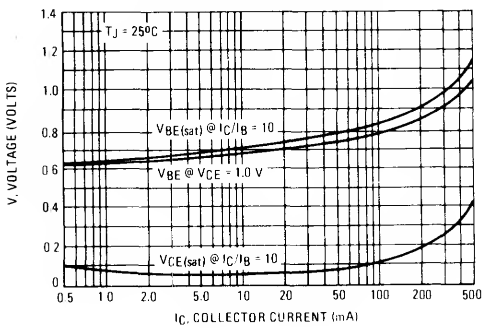
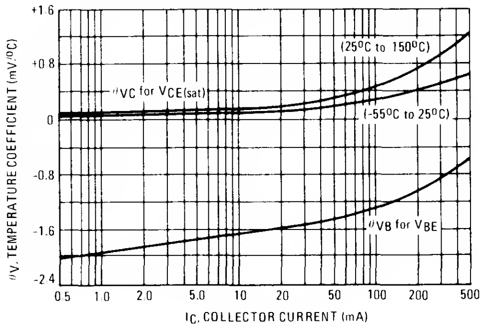


FIGURE 3 — TEMPERATURE COEFFICIENTS



NOISE FIGURE
(V_{CE} = 10 Vdc, T_A = 25°C)

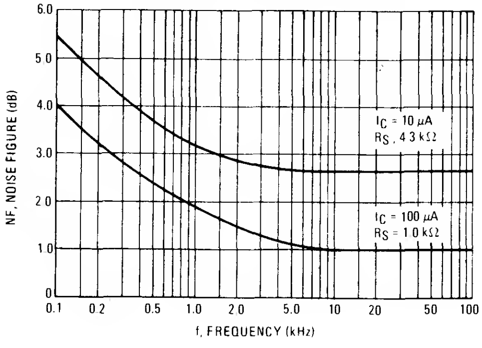


FIGURE 4 — FREQUENCY EFFECTS

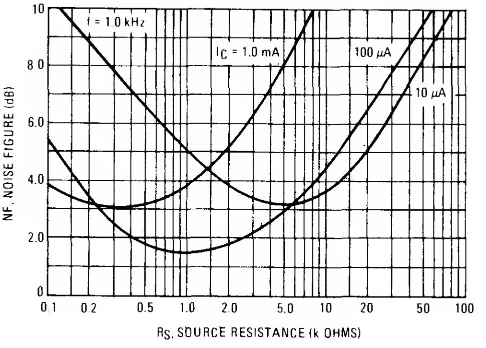


FIGURE 5 — SOURCE RESISTANCE EFFECTS

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MAXIMUM RATINGS

Rating	Symbol	MPQ6100 MPQ6600	MPQ6100A MPQ6600A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

MPQ6100,A TYPE 1
MPQ6600,A TYPE 2

CASE 646-05
TO-116

QUAD COMPLEMENTARY PAIR TRANSISTOR

PNP/NPN SILICON

Refer to 2N2919 for NPN Curves.

Refer to 2N3810 for PNP Curves.

5

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	MPQ6100,6600 MPQ6100A,6600A	$V_{(BR)CEO}$	40 45	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600 MPQ6100A,6600A	h_{FE}	50 100	— —	— —	—
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600 MPQ6100A,6600A		75 150	— —	— —	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600 MPQ6100A,6600A		75 150	— —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600 MPQ6100A,6600A		60 125	— —	— —	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	—	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	—	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	PNP NPN	C_{obo}	— —	1.2 1.8	4.0 4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	PNP	C_{ibo}	—	—	8.0	pF
	NPN		—	—	8.0	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 10 Hz to 15.7 kHz, BW = 10 kHz)		NF	—	4.0	—	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

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MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage MPQ6426 MPQ6427	V_{CEO}	 30 40		Vdc
Collector-Base Voltage MPQ6426 MPQ6427	V_{CBO}	 40 50		Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Die	Four Die Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	 500 4.0	 900 7.2	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 825 6.7	 2400 19.2	 mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

MPQ6426
MPQ6427

CASE 646-05, STYLE 1
TO-116

QUAD
DARLINGTON TRANSISTOR

NPN SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	 MPQ6426 MPQ6427	$V_{(BR)CEO}$	 30 40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPQ6426 MPQ6427	$V_{(BR)CBO}$	 40 50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	 5000 10,000	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	15	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 1 – NOISE VOLTAGE

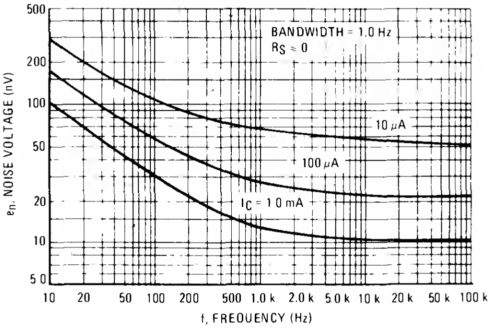


FIGURE 2 – NOISE CURRENT

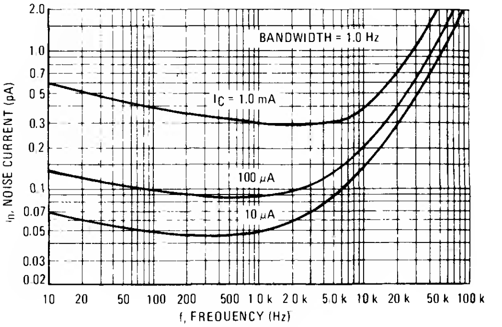


FIGURE 3 – TOTAL WIDEBAND NOISE VOLTAGE

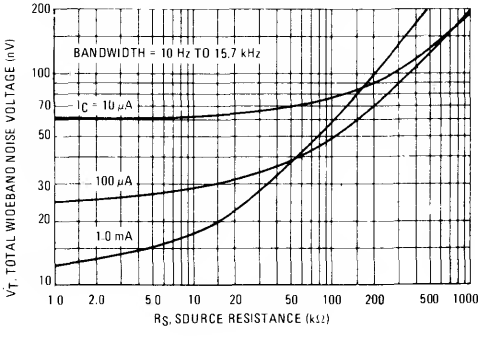
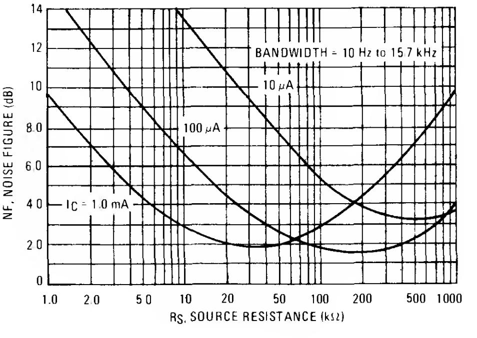


FIGURE 4 – WIDEBAND NOISE FIGURE



DYNAMIC CHARACTERISTICS

FIGURE 5 – CAPACITANCE

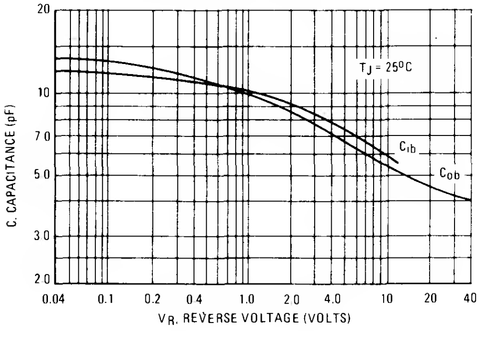
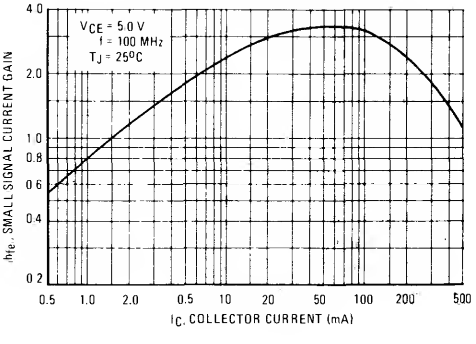


FIGURE 6 – HIGH FREQUENCY CURRENT GAIN



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	825 6.7	2400 19.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	139	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

MPQ6700

CASE 646-05, TYPE 2
TO-116

QUAD COMPLEMENTARY PAIR TRANSISTOR

PNP/NPN SILICON

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(2)				
DC Current Gain	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)		30	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		50	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		70	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}			pF
PNP		—	10	
NPN		—	8.0	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

NPN PNP

FIGURE 1 — DC CURRENT GAIN

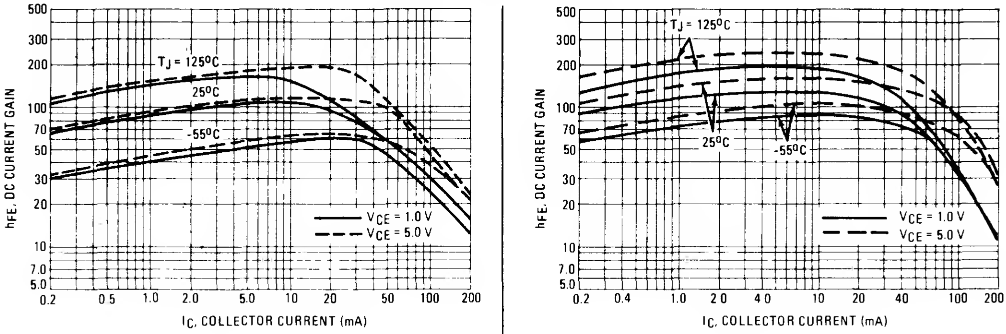


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FIGURE 2 — "ON" VOLTAGE

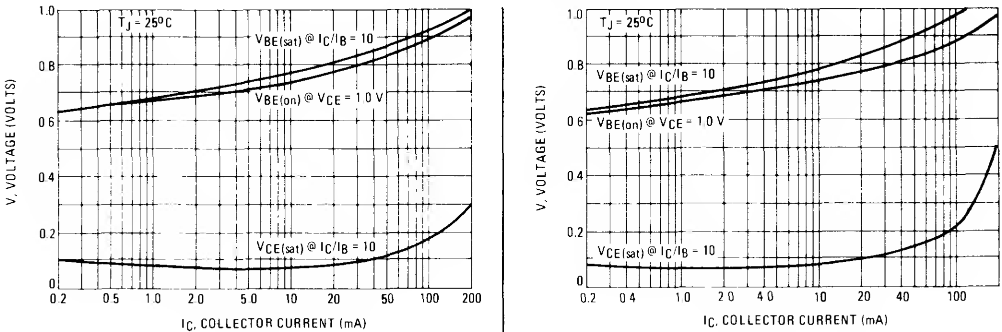
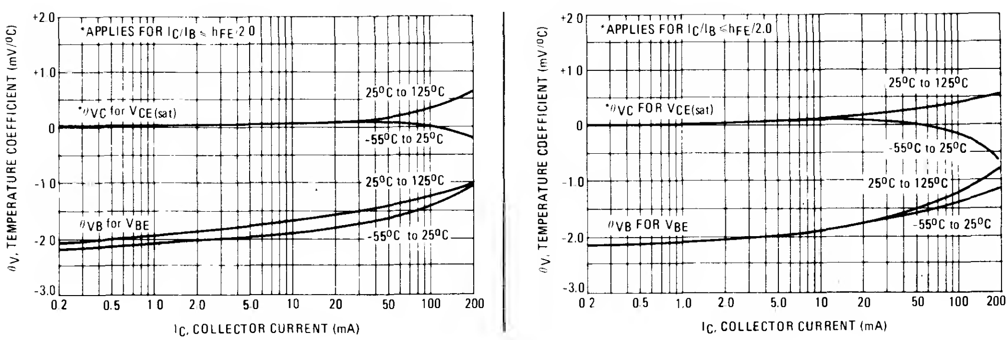
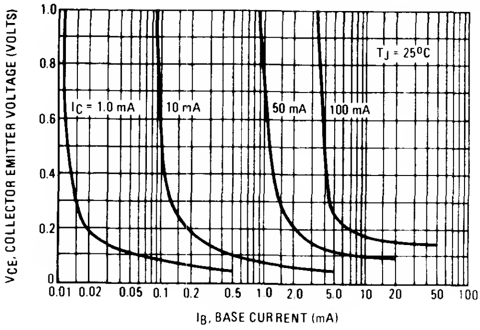


FIGURE 3 — TEMPERATURE COEFFICIENTS



NPN | PNP

FIGURE 4 – COLLECTOR SATURATION REGION



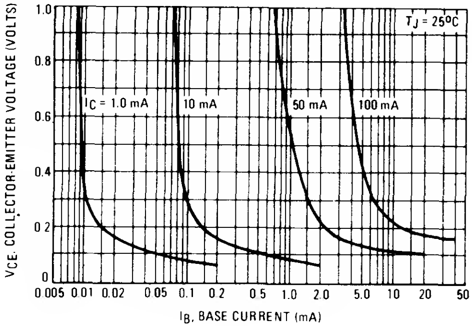
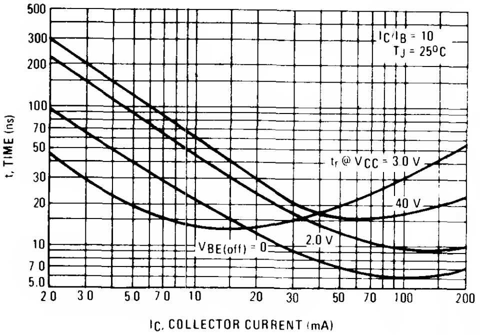


FIGURE 5 – TURN-ON TIME



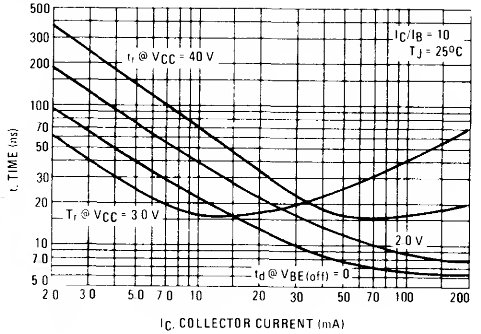
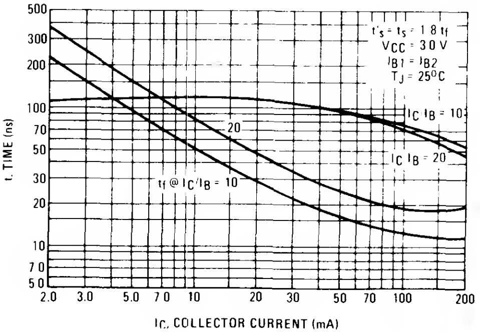
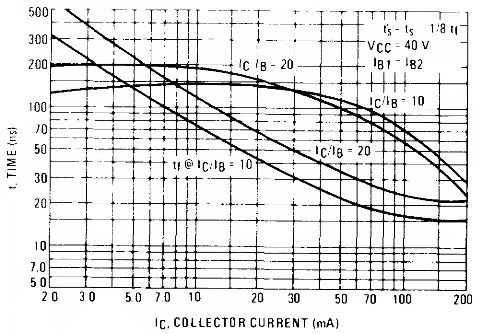


FIGURE 6 – TURN-OFF TIME





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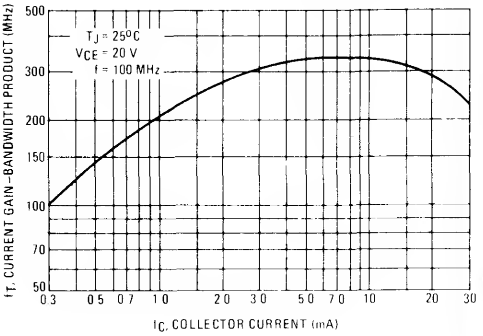
NPN | PNP

FIGURE 7 – CURRENT-GAIN – BANDWIDTH PRODUCT



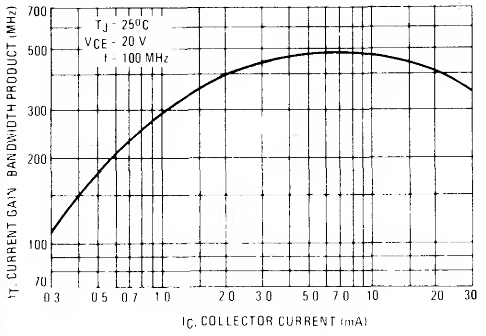
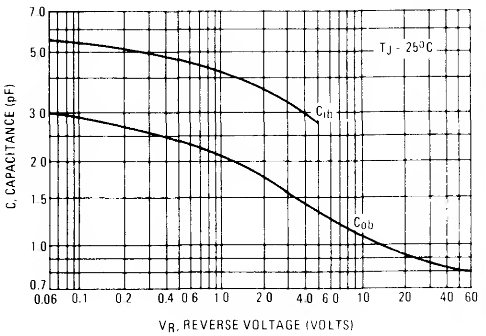
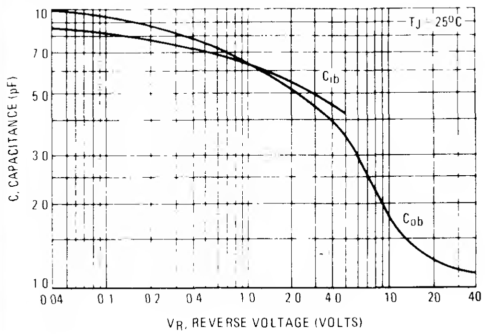


FIGURE 8 – CAPACITANCE





MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$(1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	825 6.7	2400 19.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

MPQ6842

CASE 646-05, TYPE 2
TO-116

QUAD COMPLEMENTARY PAIR TRANSISTOR

PNP/NPN SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain ($I_C = 0.5$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	30 50 70	— — —	— — —	—
Collector-Emitter Saturation Voltage ($I_C = 0.5$ mAdc, $I_B = 0.05$ mAdc, 0°C ≤ T ≤ 70°C)	$V_{CE(sat)}$	—	0.05	0.15	Vdc
Base-Emitter Saturation Voltage ($I_C = 0.5$ mAdc, $I_B = 0.05$ mAdc)	$V_{BE(sat)}$	—	0.65	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	350	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	3.0	4.5	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz) PNP NPN	C_{ibo}	— —	5.0 4.0	10 8.0	pF
SWITCHING CHARACTERISTICS ($T_A = 25°C$, $V_{CC} = 5.0$ Vdc)					
Propagation Delay Time (50% Points TP1 to TP3) (50% Points TP2 to TP4)	t_{PLH} t_{PHL}	— —	15 6.0	25 15	ns
Rise Time (0.3 V to 4.7 V, TP3 or TP4)	t_r	5.0	25	35	ns
Fall Time (4.7 V to 0.3 V, TP3 or TP4)	t_f	5.0	10	20	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

NPN | **PNP**

5

FIGURE 1 – DC CURRENT GAIN

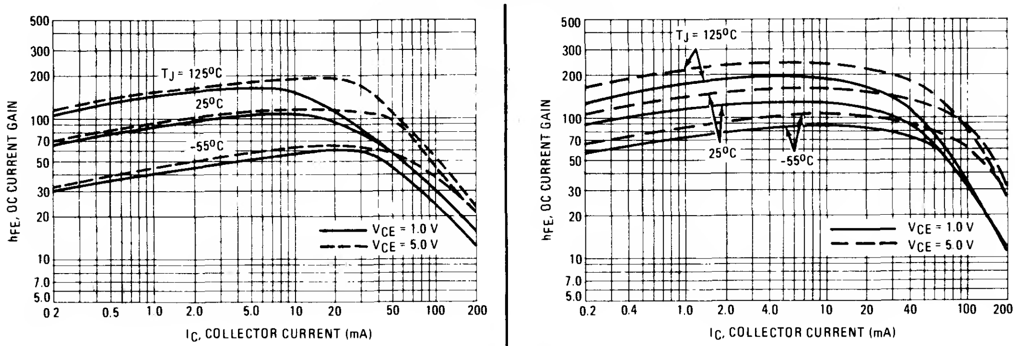


FIGURE 2 – "ON" VOLTAGE

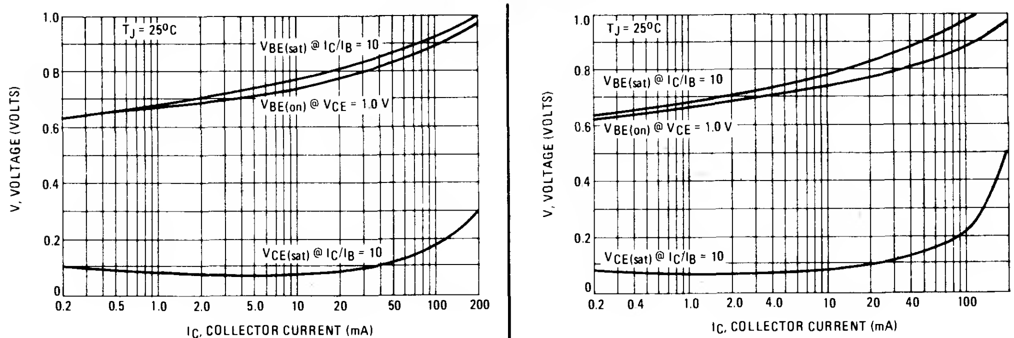


FIGURE 3 – TEMPERATURE COEFFICIENTS

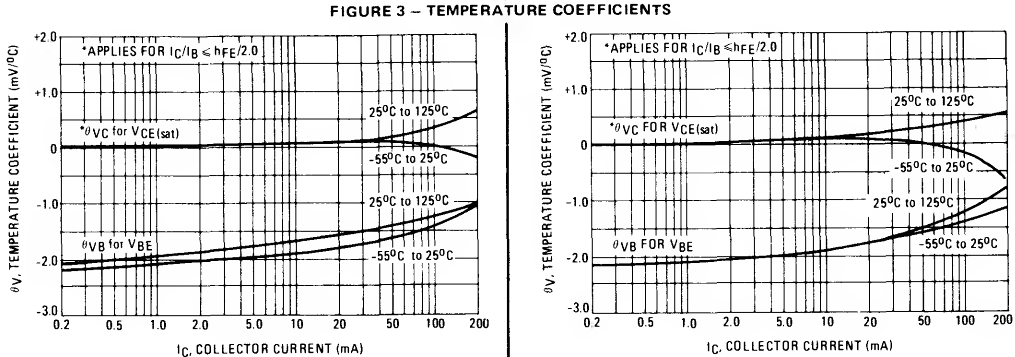


FIGURE 4 — COLLECTOR SATURATION REGION

NPN PNP

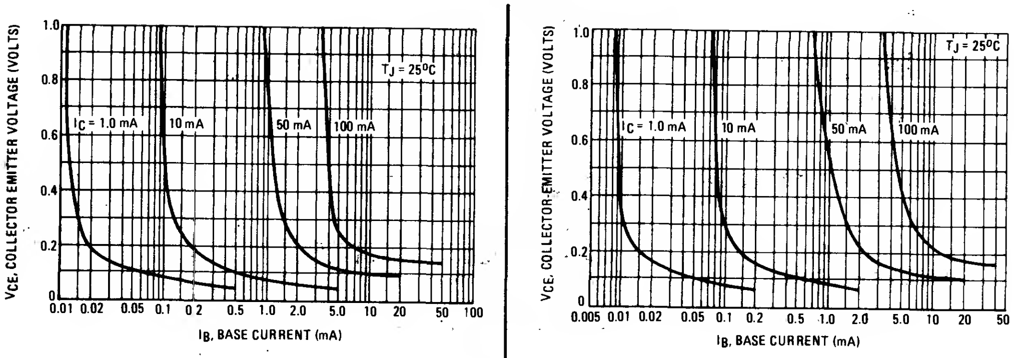
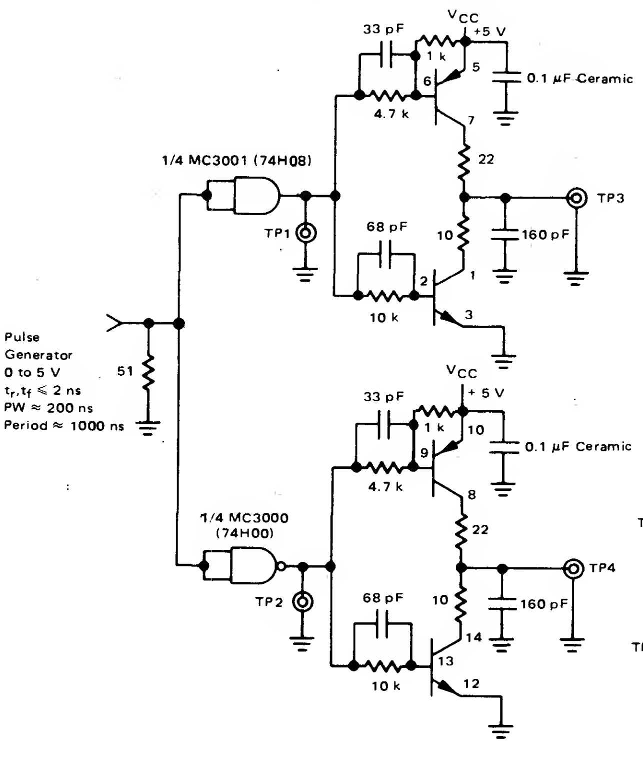
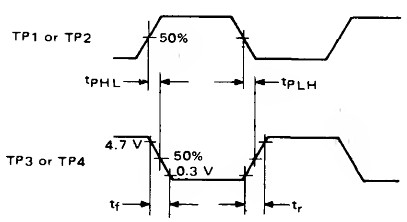


FIGURE 5 — SWITCHING TIMES TEST CIRCUIT AND WAVEFORMS



NOTES:

1. Unless otherwise noted, all resistors carbon composition ¼ W ±5%, all capacitors dipped mica ±2%.
2. Use short interconnect wiring with good power and ground busses.
3. TP1 thru TP4 are coaxial connectors to accept scope probe tip and provide a good ground.
4. Device under test is MPQ6842.
5. 160 pF load does not include stray or scope probe capacitance.
6. Scope probe resistance > 5 kΩ. Scope probe capacitance < 10 pF.



MPQ7041
MPQ7042
MPQ7043

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

NPN SILICON

5

Refer to MPQ7051 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ7041	MPQ7042	MPQ7043	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	500			mAdc
		Each Die	Four Die Equal Power		
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	750 5.98	1700 13.6		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.25 10	3.2 25.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	100 39	167 73.5	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	46 5.0	56 10	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPQ7041 MPQ7042 MPQ7043	$V_{(BR)CEO}$	150 200 250	— — —	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPQ7041 MPQ7042 MPQ7043	$V_{(BR)CBO}$	150 200 250	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 150 Vdc, I_E = 0) (V_{CB} = 180 Vdc, I_E = 0)	MPQ7041 MPQ7042 MPQ7043	I_{CBO}	— — —	— — —	100 100 100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)		h_{FE}	25 40 40	45 60 80	— — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$	—	0.3	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	80	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	2.5	5.0	pF
Input Capacitance (V_{EB} = 3.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	40	50	pF

MAXIMUM RATINGS

Rating	Symbol	MPQ7051	MPQ7052	MPQ7053	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	500			mAdc
		Each Die	Four Die Equal Power		
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	750 5.98	1700 13.6		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.25 10	3.2 25.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	100 39	167 73.5	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	46 5.0	56 10	% %

MPQ7051
MPQ7052
MPQ7053

CASE 646-05, TYPE 2
TO-116

QUAD COMPLIMENTARY PAIR TRANSISTOR

NPN/PNP SILICON

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPQ7051 MPQ7052 MPQ7053	$V_{(BR)CEO}$	150 200 250	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPQ7051 MPQ7052 MPQ7053	$V_{(BR)CBO}$	150 200 250	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 150 Vdc, I_E = 0) (V_{CB} = 180 Vdc, I_E = 0)	MPQ7051 MPQ7052 MPQ7053	I_{CBO}	— — —	250 250 250	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)		h_{FE}	25 35 25	— — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_C = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = 3.0 Vdc, I_C = 0, f = 1.0 MHz)	NPN PNP	C_{ibo}	— —	50 75	pF

DC CHARACTERISTICS

NPN | **PNP**

FIGURE 1 – DC CURRENT GAIN

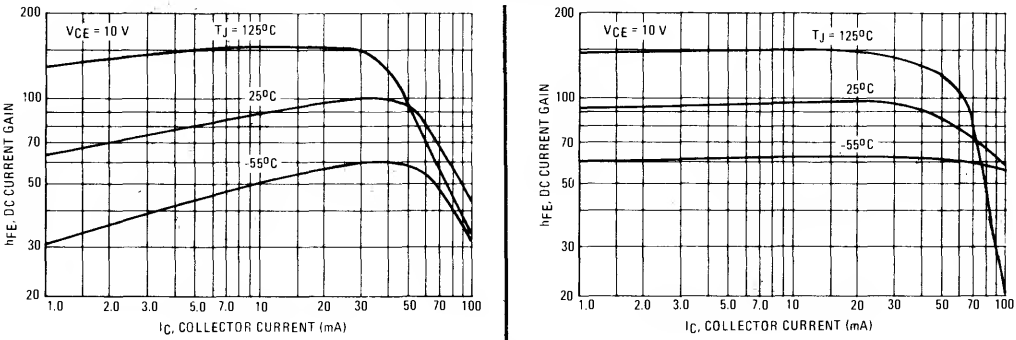


FIGURE 2 – "ON" VOLTAGES

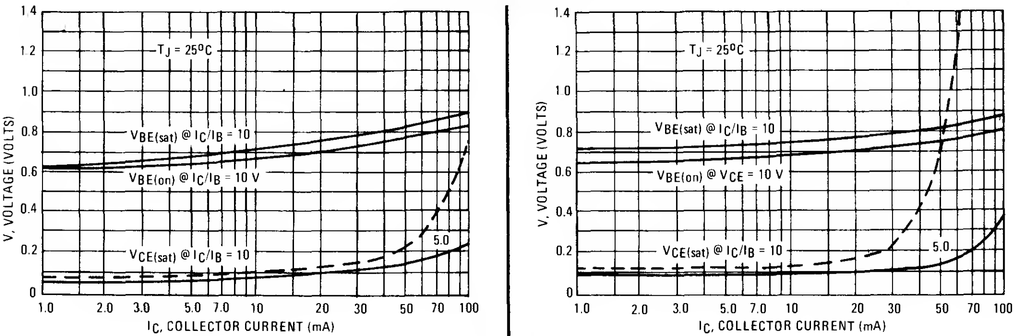
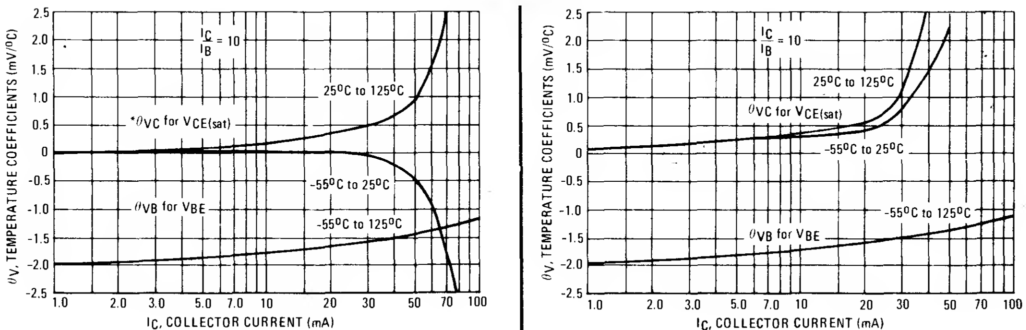


FIGURE 3 – TEMPERATURE COEFFICIENTS



MAXIMUM RATINGS

Rating	Symbol	MPQ7091	MPQ7092	MPQ7093	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	500			mAdc
		Each Die	Four Die Equal Power		
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	750 5.98	1700 13.6		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.25 10	3.2 25.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

MPQ7091
MPQ7092
MPQ7093

CASE 646-05, STYLE 1
TO-116

QUAD
AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MPQ7051 for graphs.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	100	167	°C/W
	Effective, 4 Die	39	73.5	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

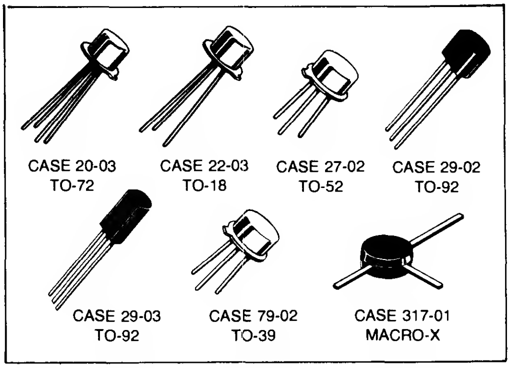
5

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	MPQ7091 MPQ7092 MPQ7093	$V_{(BR)CEO}$	150 200 250	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ µAdc, $I_E = 0$)	MPQ7091 MPQ7092 MPQ7093	$V_{(BR)CBO}$	150 200 250	— — —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ µAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 150$ Vdc, $I_E = 0$) ($V_{CB} = 180$ Vdc, $I_E = 0$)	MPQ7091 MPQ7092 MPQ7093	I_{CBO}	— — —	— — —	250 250 250	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25 35 25	40 55 50	— — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	0.3	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	70	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	3.0	5.0	pF
Input Capacitance ($V_{EB} = 3.0$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	60	75	pF

MQ982

For Specifications, See MD982 Data.



The data sheets on the following pages are designed to emphasize those FET's that by virtue of widespread industry use, ease of manufacture, and consequently low relative cost, merit first consideration for new equipment design. Package options from low-cost plastic to metal packages are available.

CAUTION:

Static electricity is a surface phenomenon which most commonly occurs when two dissimilar materials come into contact and then separate. Electro Static Discharge (ESD) damage of semiconductor components by operating personnel is quickly becoming a very prominent and significant problem. From simple bipolar designs to sensitive MOSFET structures, ESD has its unforgiving effect of degradation or destruction.

Motorola believes it is important to extend an emphasizing note of cautiousness when handling and testing *ANY* FET product. Precautions include, but are not limited to, the implementation of static safe workstations and proper handling techniques (see below). Additionally, it is very important to keep FET devices in their antistatic shipping containers and away from any static-generating materials.

HANDLING CONSIDERATIONS:

MOS Field-Effect Transistors, due to their extremely high input resistance, are subject to potential damage by the accumulation of excess static charge. To avoid possible damage to the devices while handling, testing, or in actual operation, the following procedure should be followed:

1. The leads of the devices should remain wrapped in the shorting spring except when being tested or in actual operation to avoid the build-up of static charge.
2. Avoid unnecessary handling; when handled, the devices should be picked up by the *can* instead of the leads.
3. The devices should not be inserted or removed from circuits with the power on as transient voltages may cause permanent damage to the devices.

Field-Effect Transistors

6

2N2608
2N2609

CASE 22-03, STYLE 12
TO-18 (TO-206AA)

JFET
GENERAL PURPOSE

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	−60 to +200°C	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 5.0 V)		I_{GSS}	—	10	nA
Gate Source Cutoff Voltage (V_{DS} = −5.0 V, I_D = −1.0 μA)		$V_{GS(off)}$	1.0	4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = −5.0 V, V_{GS} = 0 V)	2N2608 2N2609	I_{DSS}*	−0.9 −2.0	−4.5 −10.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = −5.0 V, f = 1.0 kHz)	2N2608 2N2609	$\lvert y_{fs} \rvert$*	1000 2500	— —	μmhos
Input Capacitance (V_{DS} = −5.0 V, V_{GS} = 1.0 V, f = 140 kHz)	2N2608 2N2609	C_{iss}	— —	17 30	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = −5.0 V, f = 1.0 kHz, R = 1.0 meg)		NF	—	3.0	dB

*Pulse Width ≤ 100 msec., Duty Cycle ≤ 10%.

2N3330

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

JFET AMPLIFIER

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.3 2.0	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10\ \mu Adc$, $V_{DS} = 0$)	$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = 10$ Vdc, $V_{DS} = 0$) ($V_{GS} = 10$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)	I_{GSS}	 — —	 10 10	 nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = -10$ Vdc, $V_{GS} = 0$)	I_{DSS}	2.0	6.0	mAdc
Gate-Source Voltage ($V_{DG} = -15$ Vdc, $I_D = 10\ \mu Adc$)	V_{GS}	—	6.0	Vdc
Drain-Source Resistance ($I_D = 100\ \mu Adc$, $V_{GS} = 0$)	r_{DS}	—	800	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance(1) ($V_{DS} = -10$ Vdc, $I_D = 2.0$ mAdc, f = 1.0 kHz) ($V_{DS} = -10$ Vdc, $I_D = 2.0$ mAdc, f = 10 MHz)	$\|y_{fs}\|$	 1500 1350	 3000 —	μmhos
Output Admittance ($V_{DS} = -10$ Vdc, $I_D = 2.0$ mAdc, f = 1.0 kHz)	$\|y_{os}\|$	—	40	μmhos
Reverse Transfer Conductance ($V_{DS} = -10$ Vdc, $I_D = 2.0$ mAdc, f = 1.0 kHz)	$\|y_{rs}\|$	—	0.1	μmhos
Input Conductance ($V_{DS} = -10$ Vdc, $I_D = 2.0$ mAdc, f = 1.0 kHz)	$\|y_{is}\|$	—	0.2	μmhos
Input Capacitance ($V_{DS} = -10$ Vdc, $V_{GS} = 1.0$ Vdc, f = 1.0 MHz)	C_{iss}	—	20	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = -5.0$ Vdc, $I_D = 1.0$ mAdc, $R_G = 1.0$ Megohm, f = 1.0 kHz)	NF	—	3.0	dB

(1) Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

2N3436
2N3437
2N3438

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
LOW-FREQUENCY

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA)		$V_{(BR)GSS}$	50	—	Vdc
Gate Reverse Current (V_{GS} = −30 V)		I_{GSS}	—	0.5	nA
Gate Source Cutoff Voltage (V_{DS} = 20 V, I_D = 1.0 nA)	2N3436 2N3437 2N3438	$V_{GS(off)}$	— — —	10.0 5.0 2.5	Vdc
Gate-Source Voltage (V_{DS} = 20 V, I_D = 1.0 μA)	2N3436 2N3437 2N3438	V_{GS}	— — —	9.8 4.8 2.3	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 20 V)	2N3436 2N3437 2N3438	I_{DSS}*	3.0 0.8 0.2	15 4.0 1.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 20 V, f = 1.0 kHz)	2N3436 2N3437 2N3438	$\|y_{fs}\|$	2500 1500 800	10000 6000 4500	μmhos
Output Admittance (V_{DS} = 30 V, f = 1.0 kHz)	2N3436 2N3437 2N3438	$\|y_{os}\|$	— — —	35 20 5	μmhos
Input Capacitance (V_{DS} = 10 V) (V_{DS} = 6.0 V) (V_{DS} = 4.0 V, f = 1.0 MHz)	 2N3436 2N3437 2N3438	C_{iss}	—	18	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 10 V, R_G = 1.0 mΩ, f = 1.0 kHz)		NF	—	2.0	dB

*Pulse Width ≤ 630 msec, Duty Cycle ≤ 10%.

2N3458
2N3459
2N3460

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
LOW-FREQUENCY/
LOW NOISE

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA)		$V_{(BR)GSS}$	−50	—	Vdc
Gate Reverse Current (V_{GS} = −30 V)		I_{GSS}	—	−.25	nA
Gate Source Cutoff Voltage (V_{DS} = 20, I_D = 1.0 μA)	2N3458 2N3459 2N3460	$V_{GS(off)}$	— — —	−7.8 −3.4 −1.8	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V_{DS} = 20 Volts)	2N3458 2N3459 2N3460	I_{DSS}*	3.0 0.8 0.2	15.0 4.0 1.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 20 Volts, f = 1.0 kHz)	2N3458 2N3459 2N3460	$\|y_{fs}\|$*	2500 1500 800	10000 6000 4500	μmhos
Output Admittance (V_{DS} = 30 Volts, f = 1.0 kHz)	2N3458 2N3459 2N3460	$\|y_{os}\|$	— — —	35 20 5	μmhos
Input Capacitance (V_{DS} = 10 V)		C_{iss}	—	18	pF
Output Capacitance (V_{DS} = 30 V)		C_{oss}	—	5.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 10 V, f = 20 Hz, R_G = 1.0 MΩ)	2N3458 2N3459 2N3460	NF	— — —	6.0 4.0 4.0	dB

*Pulse Width ≤ 100 msec, Duty Cycle ≤ 10%.

6

2N3796
2N3797

CASE 22-03, STYLE 2
TO-18 (TO-206AA)

MOSFET
LOW-POWER AUDIO

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage 2N3796 2N3797	V_{DS}	 25 20	Vdc
Gate-Source Voltage	V_{GS}	±10	Vdc
Drain Current	I_D	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Junction Temperature Range	T_J	+175	°C
Storage Channel Temperature Range	T_{stg}	−65 to +175	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (V_{GS} = −4.0 V, I_D = 5.0 μA) (V_{GS} = −7.0 V, I_D = 5.0 μA)	 2N3796 2N3797	$V_{(BR)DSX}$	 25 20	 30 25	 — —	Vdc
Gate Reverse Current(1) (V_{GS} = −10 V, V_{DS} = 0) (V_{GS} = −10 V, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 — —	 1.0 200	pAdc
Gate Source Cutoff Voltage (I_D = 0.5 μA, V_{DS} = 10 V) (I_D = 2.0 μA, V_{DS} = 10 V)	 2N3796 2N3797	$V_{GS(off)}$	 — —	 −3.0 −5.0	 −4.0 −7.0	Vdc
Drain-Gate Reverse Current(1) (V_{DG} = 10 V, I_S = 0)		I_{DGO}	—	—	1.0	pAdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	 2N3796 2N3797	I_{DSS}	 0.5 2.0	 1.5 2.9	 3.0 6.0	mAdc
On-State Drain Current (V_{DS} = 10 V, V_{GS} = +3.5 V)	 2N3796 2N3797	$I_{D(on)}$	 7.0 9.0	 8.3 14	 14 18	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz) (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)	 2N3796 2N3797 2N3796 2N3797	$\lvert y_{fs} \rvert$	 900 1500 900 1500	 1200 2300 — —	 1800 3000 — —	μmhos
Output Admittance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz)	 2N3796 2N3797	$\lvert y_{os} \rvert$	 — —	 12 27	 25 60	μmhos
Input Capacitance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)	 2N3796 2N3797	C_{iss}	 — —	 5.0 6.0	 7.0 8.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	0.5	0.8	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz, R_S = 3 megohms)		NF	—	3.8	—	dB

(1) This value of current includes both the FET leakage current as well as the leakage current associated with the test socket and fixture when measured under best attainable conditions.

TYPICAL DRAIN CHARACTERISTICS

FIGURE 1 — 2N3796

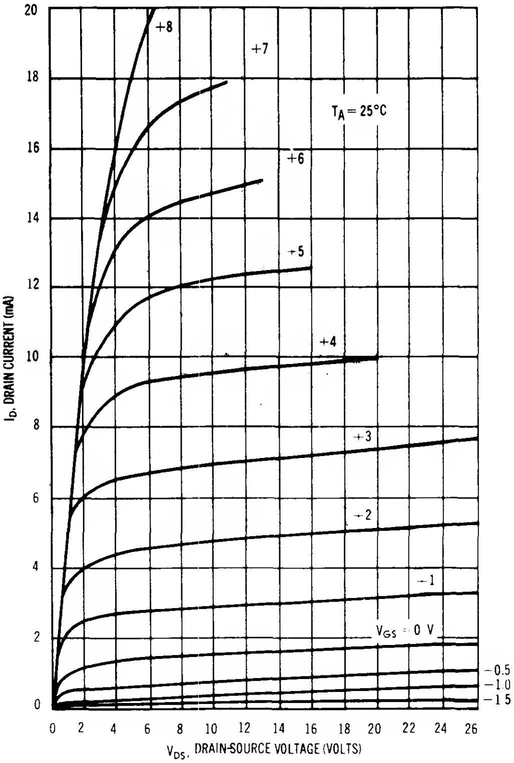
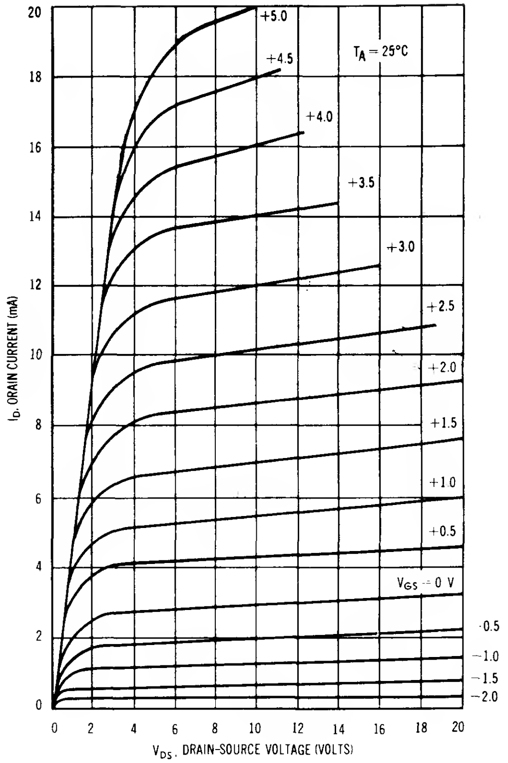


FIGURE 2 — 2N3797



COMMON SOURCE TRANSFER CHARACTERISTICS

FIGURE 3 — 2N3796

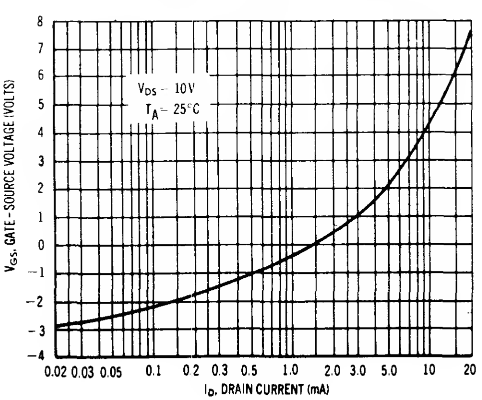


FIGURE 4 — 2N3797

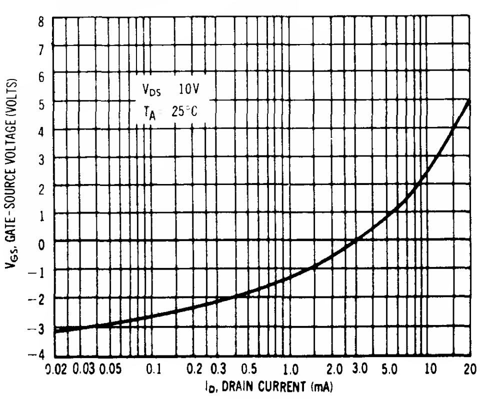


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FIGURE 5 — FORWARD TRANSFER ADMITTANCE

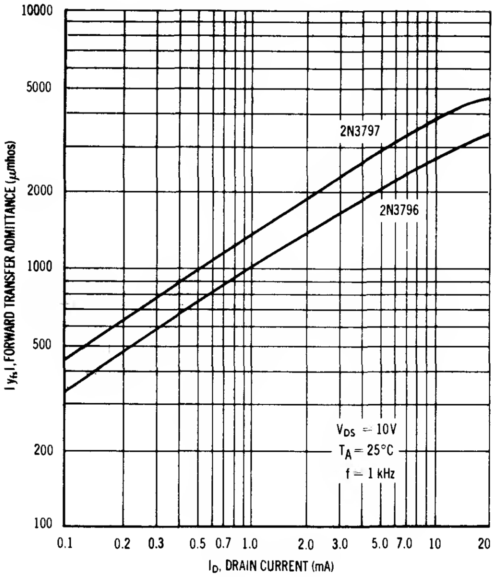

FIGURE 6 — OUTPUT ADMITTANCE

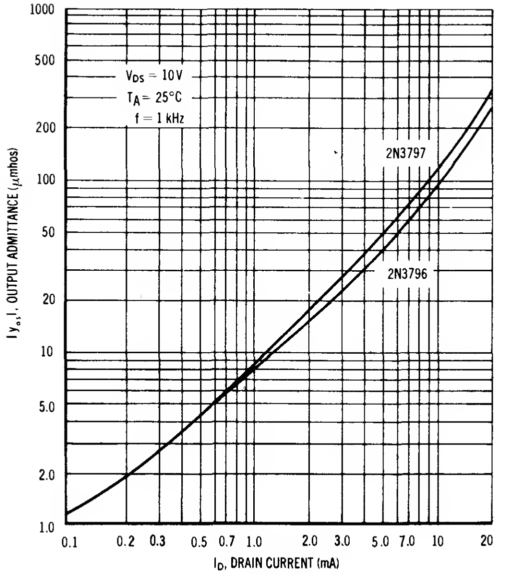

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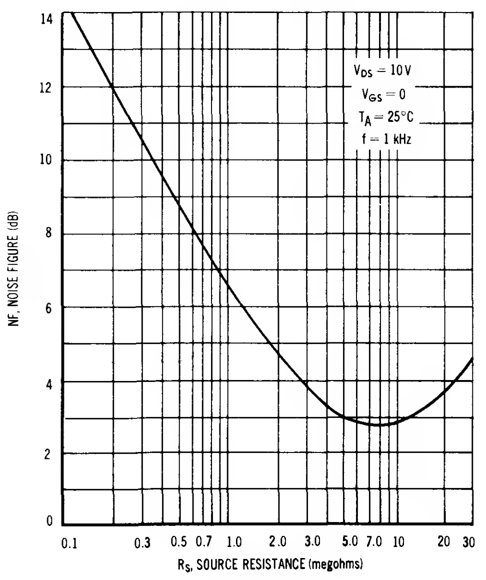
FIGURE 7 — NOISE FIGURE



2N3819

CASE 29-02, STYLE 22
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.88	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	—		Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 200 μAdc)	V_{GS}	0.5	—	7.5	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}		—	2	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 2 nAdc)	$V_{GS(off)}$		—	8	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}		—	2	μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vds, V_{GS} = 0)	I_{DSS}	2	—	20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert Y_{fs} \rvert$	2		6.5	mmhos
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	Y_{fs}	1.6		—	mmhos
Input Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{iss}	—		8	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{rss}	—		4	pF
Output Admittance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 KHz)	Y_{os}			50	μmhos

6

2N3821
2N3822
2N3824

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
LOW FREQUENCY, LOW NOISE

N-CHANNEL — DEPLETION
JAN 2N3821 AND JAN 2N3822 AVAILABLE

Refer to 2N4220 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	−50	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−50	—	Vdc
Gate Reverse Current (V_{GS} = −30 Vdc, V_{DS} = 0) (V_{GS} = −30 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 −0.1 −100	nAdc
Gate Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 15 Vdc)	 2N3821 2N3822	$V_{GS(off)}$	 — —	 −4.0 −6.0	Vdc
Gate Source Voltage (I_D = 50 μAdc, V_{DS} = 15 Vdc) (I_D = 200 μAdc, V_{DS} = 15 Vdc)	 2N3821 2N3822	V_{GS}	 −0.5 −1.0	 −2.0 −4.0	Vdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc, T_A = 150°C)	 2N3824 2N3824	$I_{D(off)}$	 — —	 0.1 100	nAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N3821 2N3822	I_{DSS}	 0.5 2.0	 2.5 10	mAdc
Static Drain-Source On Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N3824	$r_{DS(on)}$	—	250	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 2N3821 2N3822 2N3821 2N3822	$\|y_{fs}\|$	 1500 3000 1500 3000	 4500 6500 — —	μmhos
Output Admittance(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N3821 2N3822	$\|y_{os}\|$	 — —	 10 20	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz) (V_{GS} = −8.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	 2N3821 2N3822 2N3824	C_{rss}	 — — —	 3.0 3.0 3.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 megohm, f = 10 Hz, Noise Bandwidth = 5.0 Hz)	2N3821, 2N3822	NF	—	5.0	dB
Equivalent Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 10 Hz, Noise Bandwidth = 5.0 Hz)	2N3821, 2N3822	e_n	—	200	nv/Hz½

(1) Pulse Test: Pulse Width ≤ 100 ms, Duty Cycle ≤ 10%.

6

2N3823

JAN, JANTX AVAILABLE
CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu$Adc, $V_{DS} = 0$)	$V_{(BR)GSS}$	−30	—	Vdc
Gate Reverse Current ($V_{GS} = -20$ Vdc, $V_{DS} = 0$) ($V_{GS} = -20$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)	I_{GSS}	 — —	 −0.5 −500	nAdc
Gate Source Cutoff Voltage ($I_D = 0.5$ nAdc, $V_{DS} = 15$ Vdc)	$V_{GS(off)}$	—	8.0	Vdc
Gate Source Voltage ($I_D = 0.4$ mAdc, $V_{DS} = 15$ Vdc)	V_{GS}	1.0	−7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	4.0	20	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 200 MHz)	y_{fs}	 3500 3200	 6500 —	µmhos
Input Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 200 MHz)	$Re(y_{is})$	—	800	µmhos
Output Conductance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 200 MHz)	 y_{os} $Re(y_{os})$	 — —	 35 200	µmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $R_S = 1000$ ohms, f = 100 MHz)	NF	—	2.5	dB

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

2N3909,A

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

JFET
AMPLIFIER

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−20	Vdc
Drain-Gate Voltage	V_{DG}	−20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Forward Gate-Source Voltage	V_{GSF}	20	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.) (1)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current (V_{GS} = 10 Vdc, V_{DS} = 0) (V_{GS} = 10 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 10 1.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = −10 Vdc, I_D = 10 μAdc)	 2N3909 2N3909A	$V_{GS(off)}$	 — —	 8.0 8.0	Vdc
Gate Source Voltage (V_{DS} = −10 Vdc, I_D = 30 μAdc)		V_{GS}	0.3	7.9	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(2) (V_{DS} = −10 Vdc, V_{GS} = 0)	 2N3909 2N3909A	I_{DSS}	 0.3 1.0	 15 15	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(2) (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 kHz) (V_{DS} = −10 Vdc, V_{GS} = 0, f = 10 MHz)	 2N3909 2N3909A 2N3909 2N3909A	$\|y_{fs}\|$	 1000 2200 900 2000	 5000 5000 — —	μmhos
Output Admittance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	100	μmhos
Input Capacitance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	 2N3909 2N3909A	C_{iss}	 — —	 32 9.0	pF
Reverse Transfer Capacitance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	 2N3909 2N3909A	C_{rss}	 — —	 16 3.0	pF

(1) The fourth lead (case) is connected to the source for all measurements.
(2) Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

2N3966

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
HIGH-FREQUENCY AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C (Free Air)	P_D	300 1.71	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	300	°C
Storage Temperature Range	T_{stg}	−55 to 200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−30	—	Vdc
Gate Reverse Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	0.1	nA
Drain Cutoff Current (V_{DS} = 10 V, V_{GS} = −7.0 V, T_A = 150°C)	$I_{D(off)}$	—	2.0	μA
Gate Source Cutoff Voltage (I_D = 10 nA, V_{DS} = 10 V)	$V_{GS(off)}$	4.0	6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 20 V, V_{GS} = 0)	I_{DSS}	2.0	—	mA
Drain-Source "ON" Voltage (I_D = 1.0 mA, V_{GS} = 0 V)	$V_{DS(on)}$	—	0.25	Vdc
Drain Reverse Current (V_{DG} = 20 V, I_S = 0 A) (25°C) (150°C)	I_{DGO}	— —	0.1 0.2	nA μA
Static Drain-Source On Resistance (V_{GS} = 0 V, I_D = 0, f = 1.0 kHz)	$r_{DS(on)}$	—	220	Ω
SMALL-SIGNAL CHARACTERISTICS				
Input Capacitance (V_{DS} = 20 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 0 V, V_{GS} = 7.0 V, f = 1.0 MHz)	C_{rss}	—	1.5	pF
SWITCHING CHARACTERISTICS				
Delay Time (See Figure 1)	t_d	—	0.02	μsec
Rise Time (See Figure 1)	t_r	—	100	nsec
Turn-Off Time (See Figure 1)	t_{off}	—	100	nsec

2N3970
2N3971
2N3972

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{GS} = 0)		$V_{(BR)GSS}$	40	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	—	250	pAdc
Drain Reverse Current (V_{DG} = 20 Vdc, I_S = 0) (V_{DG} = 20 Vdc, I_S = 0, T_A = 150°C)		I_{DGO}	— —	250 500	pAdc nAdc
Drain Cutoff Current (V_{DS} = 20 Vdc, V_{GS} = −12 Vdc) (V_{DS} = 20 Vdc, V_{GS} = −12 Vdc, T_A = 150°C)		$I_{D(off)}$	— —	250 500	pAdc nAdc
Gate Source Voltage (V_{DS} = 20 Vdc, I_D = 1.0 nAdc)	2N3970 2N3971 2N3972	V_{GS}	4.0 2.0 0.5	10 5.0 3.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	2N3970 2N3971 2N3972	I_{DSS}	50 25 5.0	150 75 30	mAdc
Drain-Source On-Voltage (I_D = 20 mAdc, V_{GS} = 0) (I_D = 10 mAdc, V_{GS} = 0) (I_D = 5.0 mAdc, V_{GS} = 0)	2N3970 2N3971 2N3972	$V_{DS(on)}$	— — —	1.0 1.5 2.0	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	2N3970 2N3971 2N3972	$r_{DS(on)}$	— — —	30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N3970 2N3971 2N3972	$r_{ds(on)}$	— — —	30 60 100	Ohms
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	25	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{rss}	—	6.0	pF

SWITCHING CHARACTERISTICS

Characteristic	Test Condition		Symbol	Min	Max	Unit
Turn-On Delay Time	Test Condition for 2N3970: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 20 mAdc, $V_{GS(off)}$ = 10 Vdc)	2N3970 2N3971 2N3972	$t_{d(on)}$	— — —	10 15 40	ns
Rise Time	Test Condition for 2N3971: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = 5.0 Vdc)	2N3970 2N3971 2N3972	t_r	— — —	10 15 40	ns
Turn-Off Time	Test Condition for 2N3972: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 5.0 mAdc, $V_{GS(off)}$ = 3.0 Vdc)	2N3970 2N3971 2N3972	t_{off}	— — —	30 60 100	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 3.0%.

2N3993,A
2N3994,A

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

JFET
SWITCHING

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−25	Vdc
Drain-Gate Voltage	V_{DG}	−25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	Vdc
Drain Reverse Current (V_{DG} = −15 Vdc, I_S = 0) (V_{DG} = −15 Vdc, I_S = 0, T_A = 150°C)		I_{DGO}	 — —	 1.2 1.2	 nAdc μAdc
Drain Cutoff Current (V_{DS} = −10 Vdc, V_{GS} = 10 Vdc) (V_{DS} = −10 Vdc, V_{GS} = 6.0 Vdc) (V_{DS} = −10 Vdc, V_{GS} = 10 Vdc, T_A = 150°) (V_{DS} = −10 Vdc, V_{GS} = 6.0 Vdc, T_A = 150°)	 2N3993, 2N3993A 2N3994, 2N3994A 2N3993, 2N3993A 2N3994, 2N3994A	$I_{D(off)}$	 — — — —	 1.2 1.2 1.0 1.0	 nAdc μAdc
Gate Source Voltage (V_{DS} = −10 Vdc, I_D = −1.0 μAdc)	 2N3993, 2N3993A 2N3994, 2N3994A	V_{GS}	 4.0 1.0	 9.5 5.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = −10 Vdc, V_{GS} = 0)	 2N3993, 2N3993A 2N3994, 2N3994A	I_{DSS}	 10 2.0	 — —	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N3993, 2N3993A 2N3994, 2N3994A	$r_{ds(on)}$	 — —	 150 300	Ohms
Forward Transfer Admittance(1) (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N3993 2N3993A 2N3994 2N3994A	$\|y_{fs}\|$	 6.0 7.0 4.0 5.0	 12 12 10 10	mmhos
Input Capacitance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	 2N3993, 2N3994 2N3993A, 2N3994A	C_{iss}	 — —	 16 12	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz) (V_{DS} = 0, V_{GS} = 6.0 Vdc, f = 1.0 MHz)	 2N3993 2N3993A 2N3994 2N3994A	C_{rss}	 — — — —	 4.5 3.0 5.0 3.5	pF

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

2N4091
2N4092
2N4093

JAN, JTX AVAILABLE
CASE 22-03, STYLE 3
TO-18 (TO-206AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	—	Vdc
Drain-Gate Breakdown Voltage (I_D = 1.0 μAdc, I_S = 0)		$V_{(BR)DGO}$	40	—	Vdc
Gate Source Cutoff Voltage (V_{DS} = 20 Vdc, I_D = 1.0 nAdc)	 2N4091 2N4092 2N4093	$V_{GS(off)}$	 5.0 2.0 1.0	 10 7.0 5.0	Vdc
Source Reverse Current (V_{SG} = 20 Vdc, I_D = 0)		I_{SGO}	—	0.2	nAdc
Drain Reverse Current (V_{DG} = 20 Vdc, I_S = 0) (V_{DG} = 20 Vdc, I_D = 0, T_A = 150°C)		I_{DGO}	 — —	 0.2 0.4	nAdc μAdc
Drain-Cutoff Current (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 8.0 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 6.0 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc, T_A = 150°C) (V_{DS} = 20 Vdc, V_{GS} = 8.0 Vdc, T_A = 150°C) (V_{DS} = 20 Vdc, V_{GS} = 6.0 Vdc, T_A = 150°C)	 2N4091 2N4092 2N4093 2N4091 2N4092 2N4093	$I_{D(off)}$	 — — — — — —	 0.2 0.2 0.2 0.4 0.4 0.4	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 20 Vdc, V_{GS} = 0)	 2N4091 2N4092 2N4093	I_{DSS}*	 30 15 8.0	 — — —	mAdc
Drain-Source On-Voltage (I_D = 6.6 mAdc, V_{GS} = 0) (I_D = 4.0 mAdc, V_{GS} = 0) (I_D = 2.5 mAdc, V_{GS} = 0)	 2N4091 2N4092 2N4093	$V_{DS(on)}$	 — — —	 0.2 0.2 0.2	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 2N4091 2N4092 2N4093	$r_{DS(on)}$	 — — —	 30 50 80	Ohms

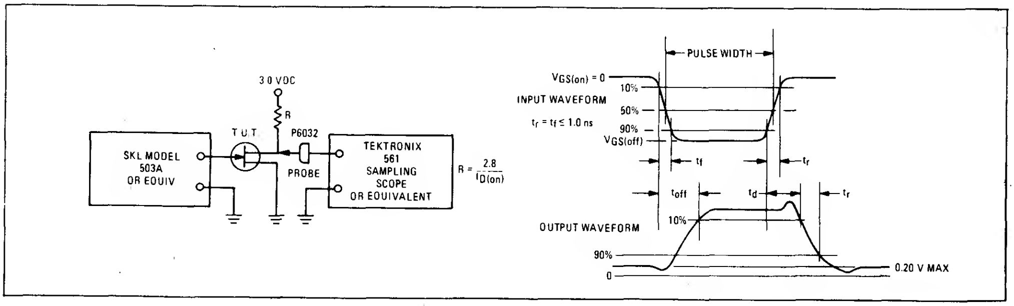
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

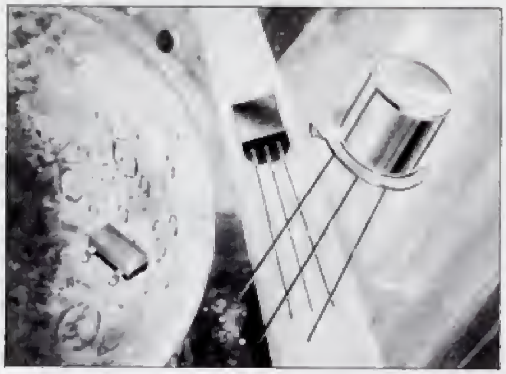
Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4091 2N4092 2N4093	$r_{ds(on)}$	— — —	30 50 80	Ohms
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	16	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 20 Vdc, f = 1.0 MHz)		C_{rss}	—	5.0	pF
SWITCHING CHARACTERISTICS					
Delay Time (See Figure 1) ($I_{D(on)}$ = 6.6 mAdc) ($I_{D(on)}$ = 4.0 mAdc) ($I_{D(on)}$ = 2.5 mAdc)	2N4091 2N4092 2N4093	t_d	— — —	15 15 20	ns
Rise Time (See Figure 1) ($I_{D(on)}$ = 6.6 mAdc) ($I_{D(on)}$ = 4.0 mAdc) ($I_{D(on)}$ = 2.5 mAdc)	2N4091 2N4092 2N4093	t_r	— — —	10 20 40	ns
Turn-Off Time (See Figure 1) ($V_{GS(off)}$ = 12 Vdc) ($V_{GS(off)}$ = 8.0 Vdc) ($V_{GS(off)}$ = 6.0 Vdc)	2N4091 2N4092 2N4093	t_{off}	— — —	40 60 80	ns

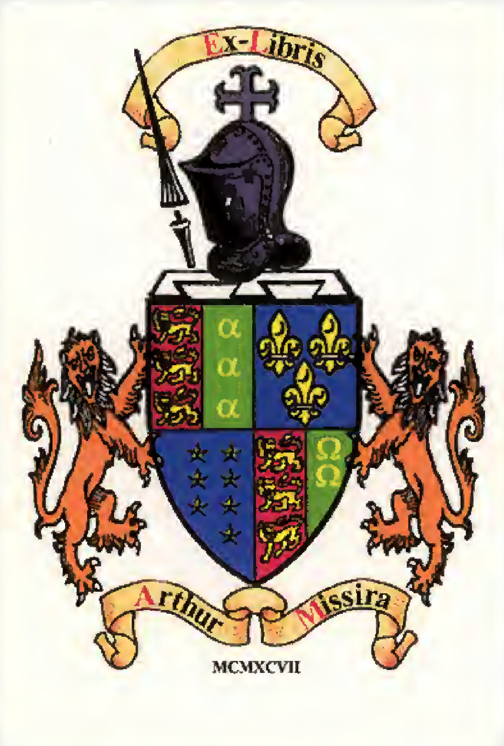
*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

6

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT






Ex-Libris
Arthur Missira
MCMXCVII

2N4117,A
2N4118,A
2N4119,A

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
AMPLIFIER

N-CHANNEL — DEPLETION

Refer to MPF4117 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−40	Vdc
Drain-Gate Voltage	V_{DG}	−40	Vdc
Gate Current	I_G	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Lead Temperature (1/16" from case for 10 s)	T_L	255	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)	2N4117,4118,4119 2N4117A,4118A,4119A	I_{GSS}	— —	−10 −1.0	pAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)	2N4117,4118,4119 2N4117A,4118A,4119A		— —	−25 −2.5	nAdc
Gate Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 10 Vdc)	2N4117,A 2N4118,A 2N4119,A	$V_{GS(off)}$	−0.6 −1.0 −2.0	−1.8 −3.0 −6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 10 Vdc, V_{GS} = 0)	2N4117,A 2N4118,A 2N4119,A	I_{DSS}	0.03 0.08 0.20	0.09 0.24 0.60	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	3.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.5	pF
Forward Transconductance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4117,A 2N4118,A 2N4119,A	g_{fs}	70 80 100	210 250 330	μmhos
Output Conductance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4117,A 2N4118,A 2N4119,A	g_{os}	— — —	3.0 5.0 10	μmhos

(1) I_{DSS} is measured during a 2.0-ms interval 100 ms after power is applied. (NOT a JEDEC condition.)

2N4220 thru 2N4222

2N4220,A thru 2N4222,A

CASE 20-03, STYLE 3
TO-72 (TO-206AF)

JFET
LOW-FREQUENCY, LOW NOISE

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	−30	Vdc
Drain Current	I_D	15	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Channel Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−30	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 — —	 −0.1 −100	nAdc
Gate Source Cutoff Voltage (I_D = 0.1 nAdc, V_{DS} = 15 Vdc)	 2N4220,A 2N4221,A 2N4222,A	$V_{GS(off)}$	 — — —	 — — —	 −4 −6 −8	Vdc
Gate Source Voltage (I_D = 50 μAdc, V_{DS} = 15 Vdc) (I_D = 200 μAdc, V_{DS} = 15 Vdc) (I_D = 500 μAdc, V_{DS} = 15 Vdc)	 2N4220,A 2N4221,A 2N4222,A	V_{GS}	 −0.5 −1.0 −2.0	 — — —	 −2.5 −5.0 −6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N4220,A 2N4221,A 2N4222,A	I_{DSS}	 0.5 2.0 5.0	 — — —	 3.0 6.0 15	mAdc
Static Drain-Source On Resistance (V_{DS} = 0, V_{GS} = 0)	 2N4220,A 2N4221,A 2N4222,A	$r_{DS(on)}$	 — — —	 500 400 300	 — — —	Ohms
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance Common Source* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N4220,A 2N4221,A 2N4222,A	$\|y_{fs}\|$	 1000 2000 2500	 — — —	 4000 5000 6000	μmhos
Output Admittance Common Source (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N4220,A 2N4221,A 2N4222,A	$\|y_{os}\|$	 — — —	 — — —	 10 20 40	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	4.5	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.2	2.0	pF
Common-Source Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 30 MHz)		C_{osp}	—	1.5	—	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 megohm, f = 100 Hz)	2N4220A	NF	—	—	2.5	dB
	2N4221A		—	—	2.5	
	2N4222A		—	—	2.5	

*Pulse Test: Pulse Width = 630 ms, Duty Cycle = 10%.

FIGURE 1 — NOISE FIGURE versus FREQUENCY

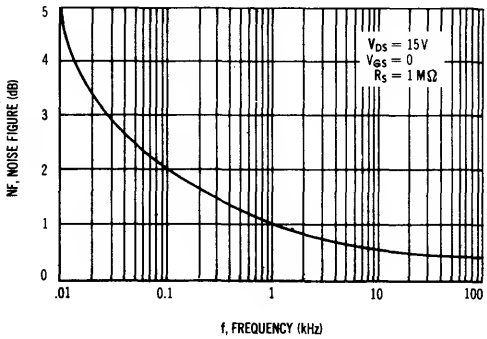


FIGURE 2 — NOISE FIGURE versus SOURCE RESISTANCE

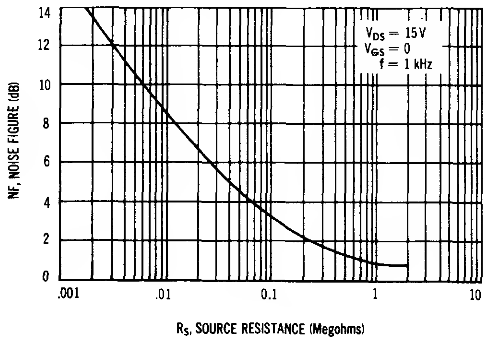


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FIGURE 3 — TYPICAL DRAIN CHARACTERISTICS
$V_{GS(off)} \cong -1.2$ VOLTS

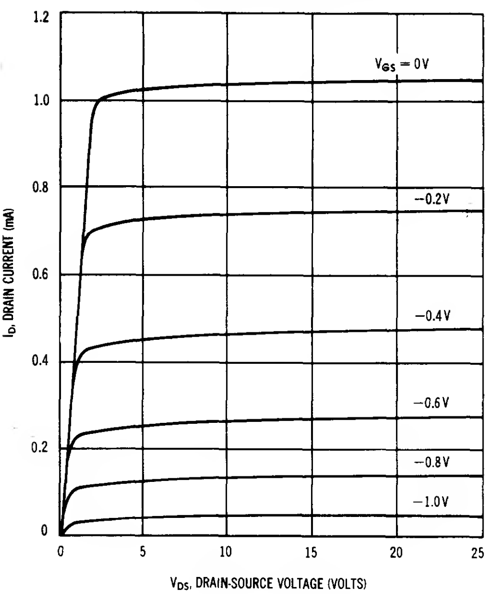


FIGURE 4 — COMMON SOURCE TRANSFER CHARACTERISTICS
$V_{GS(off)} \cong -1.2$ VOLTS

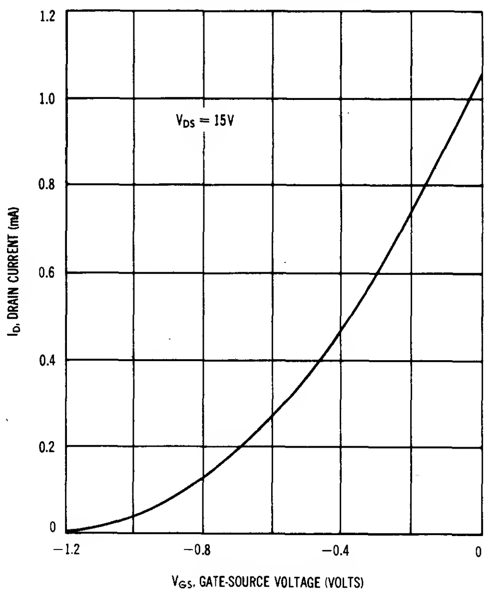


FIGURE 5 — TYPICAL DRAIN CHARACTERISTICS
$V_{GS(off)} \cong -3.5$ VOLTS

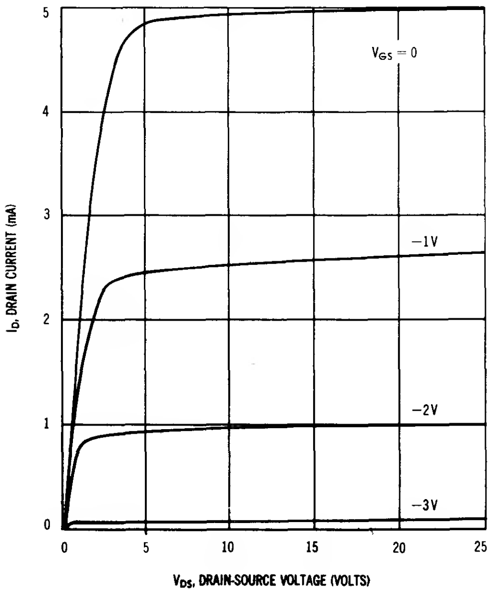


FIGURE 6 — COMMON SOURCE TRANSFER CHARACTERISTICS
$V_{GS(off)} \cong -3.5$ VOLTS

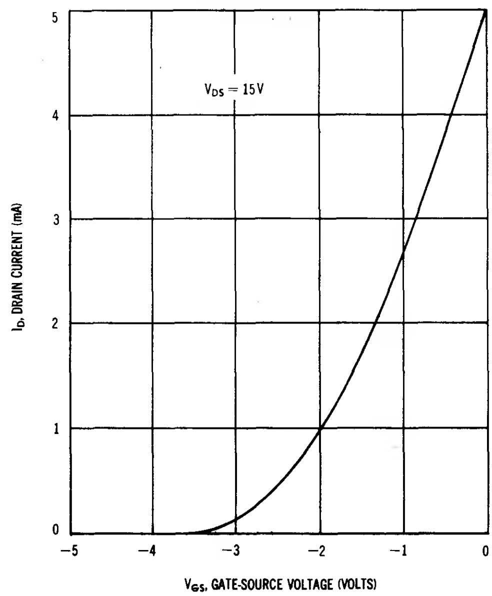


FIGURE 7 — TYPICAL DRAIN CHARACTERISTICS
$V_{GS(off)} \cong -5.8$ VOLTS

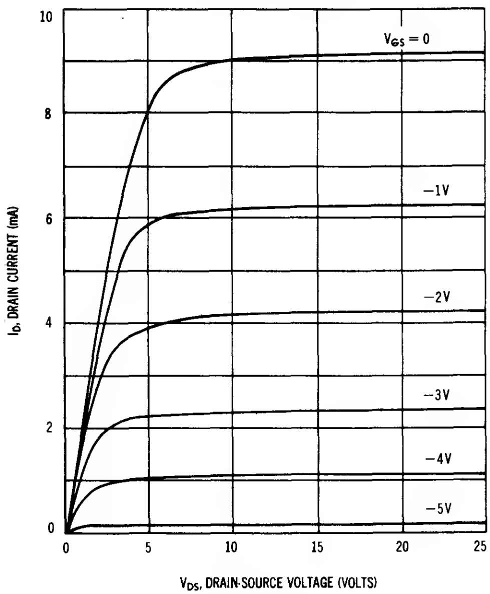
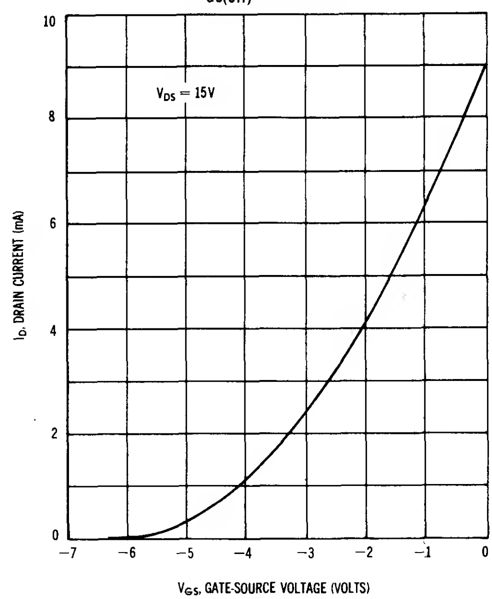


FIGURE 8 — COMMON SOURCE TRANSFER CHARACTERISTICS
$V_{GS(off)} \cong -5.8$ VOLTS



NOTES:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS} (See Figure 10).
2. Figures 8, 9, 10: Data taken in a standard printed circuit with a TO-18 type socket mounting and 1/4" lead length.

2N4223
2N4224

CASE 20-03, STYLE 3
TO-72 (TO-206AF)

JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	−30	Vdc
Drain Current	I_D	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating and Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−30	—	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0)	2N4223 2N4224	I_{GSS}	— —	−0.25 −0.50	nAdc
(V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 100°C)	2N4223 2N4224		— —	−250 −500	
Gate Source Cutoff Voltage (I_D = 0.25 nAdc, V_{DS} = 15 Vdc) (I_D = 0.50 nAdc, V_{DS} = 15 Vdc)	2N4223 2N4224	$V_{GS(off)}$	−1.2 —	−8.0 −8.0	Vdc
Gate Source Voltage (I_D = 0.3 mAdc, V_{DS} = 15 Vdc) (I_D = 0.2 mAdc, V_{DS} = 15 Vdc)	2N4223 2N4224	V_{GS}	−1.0 −1.0	−7.0 −7.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	2N4223 2N4224	I_{DSS}	3.0 2.0	18 20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)*	2N4223 2N4224	$\lvert y_{fs} \rvert$	3000 2000	7000 7500	μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	2N4223 2N4224		2700 1700	— —	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{is})$	—	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{os})$	—	200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	2.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 k ohm, f = 200 MHz)	2N4223	NF	—	5.0	dB
Small-Signal Power Gain Common Source (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	2N4223	G_{ps}	10	—	dB

*Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

FIGURE 1—NOISE FIGURE AND POWER GAIN TEST CIRCUIT

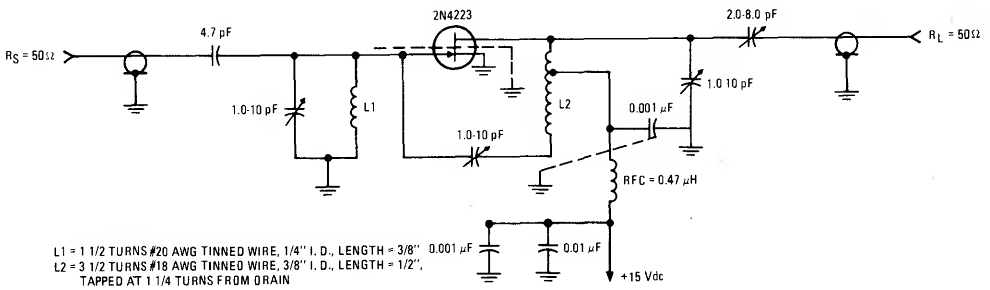


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FIGURE 2 – DRAIN CURRENT versus GATE-SOURCE VOLTAGE

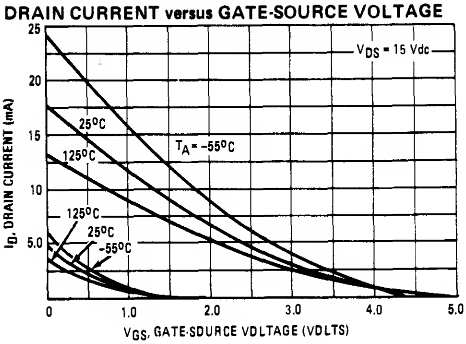


FIGURE 3 – TEMPERATURE COEFFICIENT FOR DRAIN CURRENT

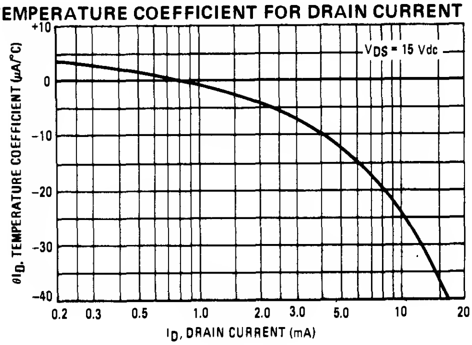


FIGURE 4 – FORWARD TRANSFER ADMITTANCE versus GATE-SOURCE VOLTAGE

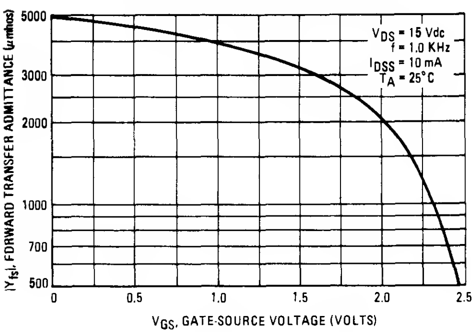


FIGURE 5 – TEMPERATURE COEFFICIENT FOR Y_{fs} versus DRAIN CURRENT

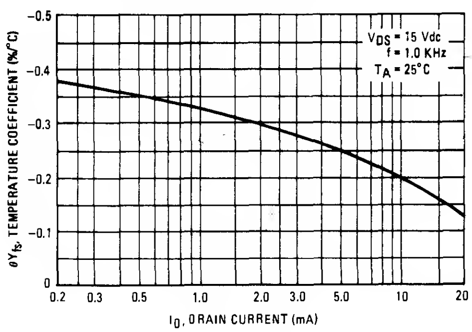


FIGURE 6 – CAPACITANCES

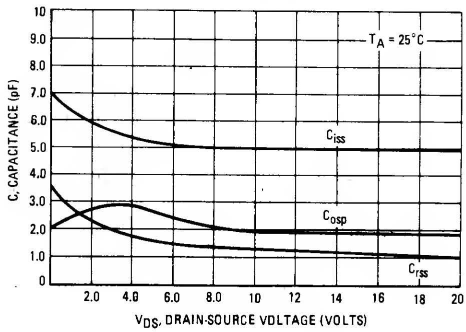


FIGURE 7 – COMMON SOURCE NOISE FIGURE versus SOURCE RESISTANCE

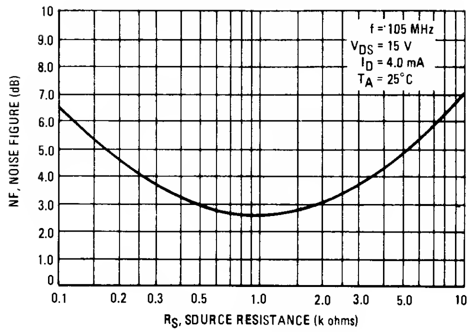


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

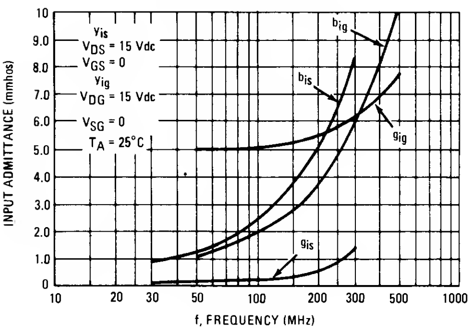


FIGURE 9 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

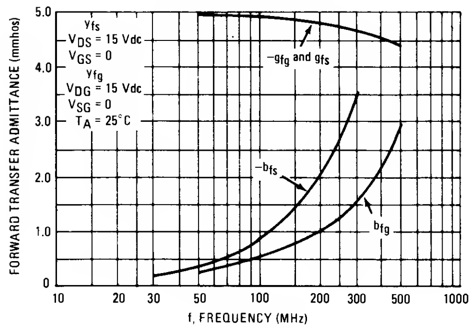


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

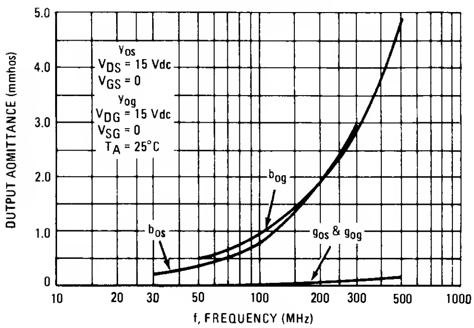


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

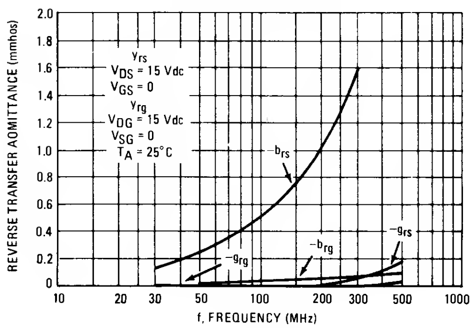


FIGURE 12 – POWER GAIN versus FREQUENCY

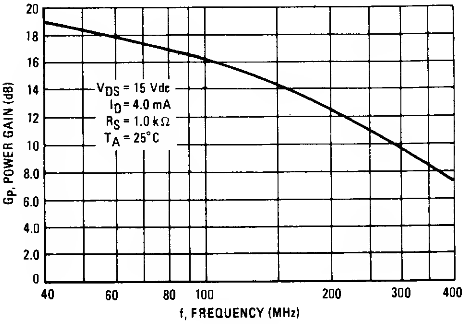
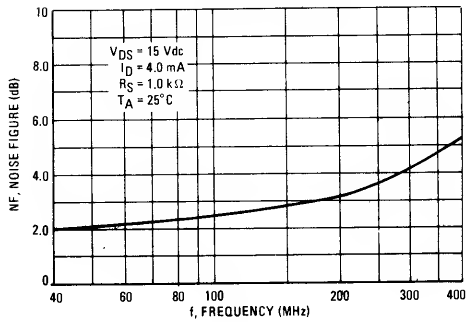


FIGURE 13 – COMMON SOURCE NOISE FIGURE versus FREQUENCY



6

2N4338
2N4339
2N4340
2N4341

CASE 22-03, STYLE 3
TO-18 (TO-206AA)

JFET
LOW-FREQUENCY, LOW NOISE

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Reverse Gate-Source Voltage	V_{GSR}	50	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu A$)		$V_{(BR)GSS}$	50	—	Vdc
Gate Reverse Current ($V_{GS} = -30$ V)		I_{GSS}	—	0.1	nA
Gate Source Cutoff Voltage ($V_{DS} = 15$ V, $I_D = 0.1\ \mu A$)	2N4338 2N4339 2N4340 2N4341	$V_{GS(off)}$	−0.3 −0.6 −1.0 −2.0	−1.0 −1.8 −3.0 −6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 15$ V)	2N4338 2N4339 2N4340 2N4341	I_{DSS}*	0.2 0.5 1.2 3.0	0.6 1.5 3.6 9.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15$ V, f = 1.0 kHz)	2N4338 2N4339 2N4340 2N4341	$\|y_{fs}\|$*	600 800 1300 2000	1800 2400 3000 4000	μmhos
Output Admittance ($V_{DS} = 15$ V, f = 1.0 kHz)	2N4338 2N4339 2N4340 2N4341	$\|y_{os}\|$	— — — —	5.0 15 30 60	μmhos
Input Capacitance ($V_{DS} = 15$ V, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ V, f = 1.0 MHz)		C_{rss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 15$ Volts, f = 1.0 kHz, $R_G = 1.0$ MΩ)		NF	—	1.0	dB

*Pulse Test: Pulse Width ≤ 630 msec, Duty Cycle ≤ 10%.

2N4342

CASE 29-02, STYLE 7
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY, LOW NOISE

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−25	Vdc
Drain-Gate Voltage	V_{DG}	−25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +125	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 65°C)	I_{GSS}	 — —	 10 0.5	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = −10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	1.0	5.5	Vdc
Gate Source Voltage (V_{DS} = −10 Vdc, I_D = 0.4 mAdc) (V_{DS} = −10 Vdc, I_D = 1.0 mAdc)	V_{GS}	0.7	5.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = −10 Vdc, V_{GS} = 0)	I_{DSS}	4.0	12	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	—	700	Ohms
Forward Transfer Admittance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}\|$	2000	6000	μmhos
Output Admittance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	75	μmhos
Common Source Forward Transconductance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	$Re(y_{fs})$	1500	—	μmhos
Input Capacitance (V_{DS} = −10 Vdc, V_{CS} = 0, f = 1.0 MHz)	C_{iss}	—	20	pF
Reverse Transfer Capacitance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	5.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = −10 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 15 Hz)	NF	—	1.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = −10 Vdc, V_{GS} = 0, f = 100 Hz, BW = 15 Hz)	E_n	—	0.08	$\mu V/\sqrt{Hz}$

2N4351

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOS FET SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage*	V_{GS}	30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	800 4.56	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

*Transient potentials of ±75 Volt will not cause gate-oxide failure.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = 10\ \mu A$, $V_{GS} = 0$)	$V_{(BR)DSX}$	25	—	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = 10$ V, $V_{GS} = 0$) $T_A = 25°C$ $T_A = 150°C$	I_{DSS}	— —	10 10	nAdc μAdc
Gate Reverse Current ($V_{GS} = \pm 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	±10	pAdc
ON CHARACTERISTICS				
Gate Threshold Voltage ($V_{DS} = 10$ V, $I_D = 10\ \mu A$)	$V_{GS(Th)}$	1.0	5	Vdc
Drain-Source On-Voltage ($I_D = 2.0$ mA, $V_{GS} = 10$ V)	$V_{DS(on)}$	—	1.0	V
On-State Drain Current ($V_{GS} = 10$ V, $V_{DS} = 10$ V)	$I_{D(on)}$	3.0	—	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 10$ V, $I_D = 2.0$ mA, f = 1.0 kHz)	$\|y_{fs}\|$	1000	—	μmho
Input Capacitance ($V_{DS} = 10$ V, $V_{GS} = 0$, f = 140 kHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, f = 140 kHz)	C_{rss}	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)} = 10$ V, f = 140 kHz)	$C_{d(sub)}$	—	5.0	pF
Drain-Source Resistance ($V_{GS} = 10$ V, $I_D = 0$, f = 1.0 kHz)	$r_{ds(on)}$	—	300	ohms

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Delay (Fig. 5)	$I_D = 2.0$ mAdc, $V_{DS} = 10$ Vdc, $V_{GS} = 10$ Vdc) (See Figure 9; Times Circuit Determined)	t_{d1}	—	45	ns
Rise Time (Fig. 6)		t_r	—	65	ns
Turn-Off Delay (Fig. 7)		t_{d2}	—	60	ns
Fall Time (Fig. 8)		t_f	—	100	ns

6

FIGURE 1 — FORWARD TRANSFER ADMITTANCE

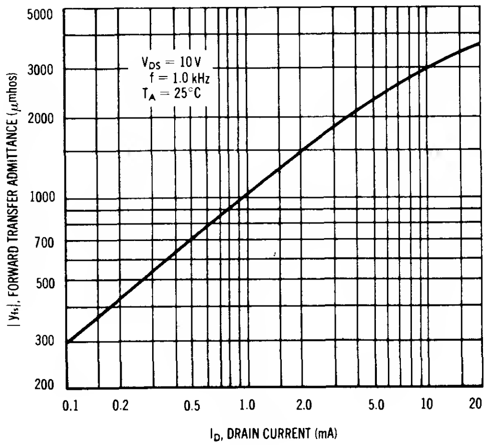


FIGURE 2 — TRANSFER CHARACTERISTICS

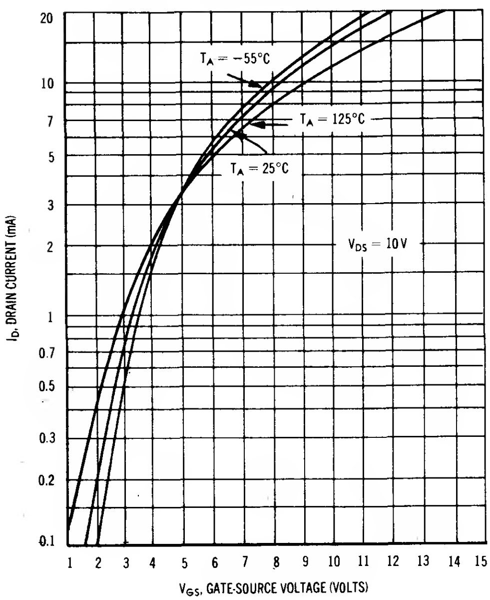


FIGURE 3 — DRAIN-SOURCE "ON" RESISTANCE

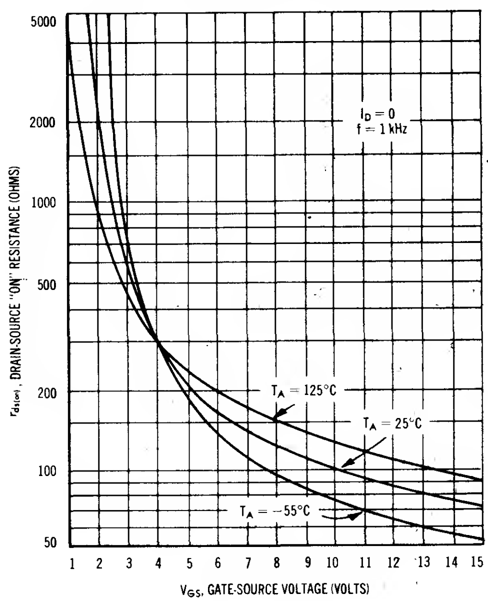
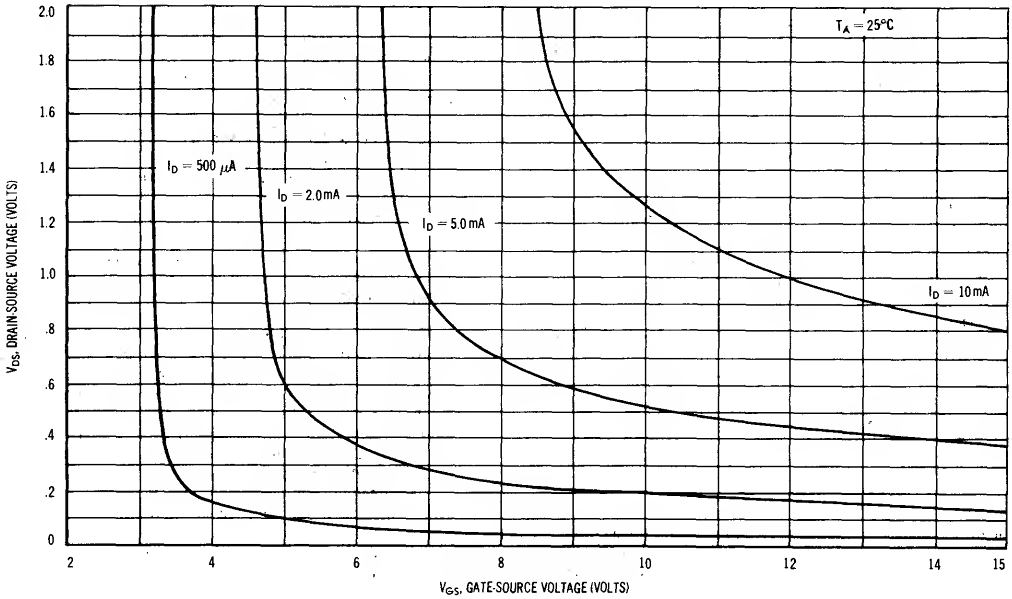


FIGURE 4 — "ON" DRAIN-SOURCE VOLTAGE



6

SWITCHING CHARACTERISTICS
($T_A = 25°C$)

FIGURE 5 — TURN-ON DELAY TIME

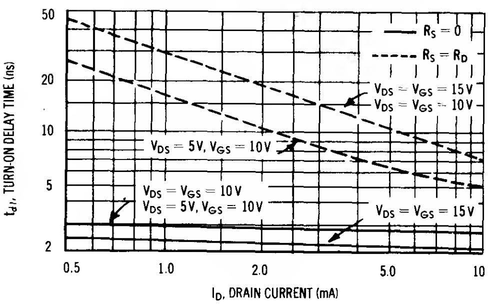


FIGURE 6 — RISE TIME

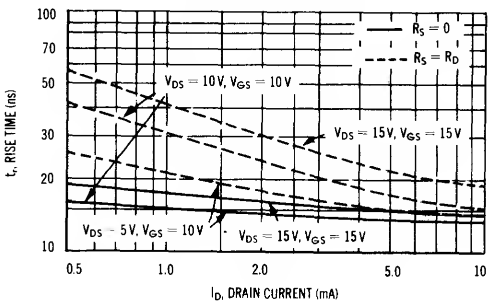


FIGURE 7 — TURN-OFF DELAY TIME

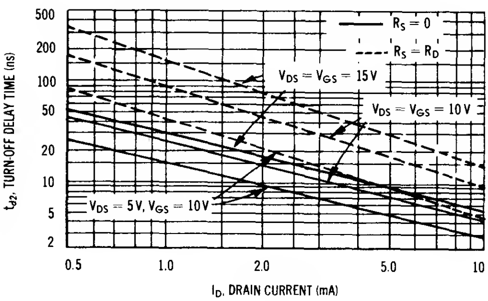


FIGURE 8 — FALL TIME

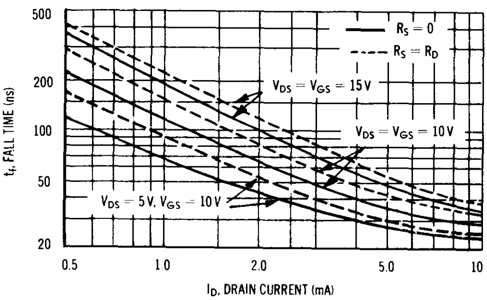
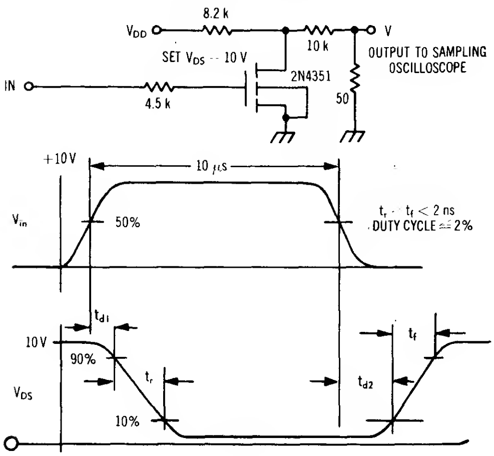


FIGURE 9 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

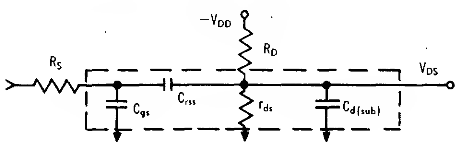
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged, V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 10 — SWITCHING CIRCUIT MOSFET EQUIVALENT MODEL



6

2N4352

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOS FET
SWITCHING

P-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Gate Current	I_G	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	800 4.56	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = −10 μA, V_{GS} = 0)		$V_{(BR)DSX}$	−25	—	Vdc
Zero-Gate-Voltage Drain Current (V_{DS} = −10 V, V_{GS} = 0) T_A = 25°C T_A = 150°C		I_{DSS}	— —	−10 −10	nAdc μAdc
Gate Reverse Current (V_{GS} = ±30 V, V_{DS} = 0)		I_{GSS}	—	±10	pAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = −10 V, I_D = −10 μA)		$V_{GS(Th)}$	−1.0	−5.0	Vdc
Drain-Source On-Voltage (I_D = −2.0 mA, V_{GS} = −10 V)		$V_{DS(on)}$	—	−1.0	V
On-State Drain Current (V_{GS} = −10 V_{DS} = −10 V)		$I_{D(on)}$	−3.0	—	mA
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = −10 V, I_D = 0, f = 1.0 kHz)		$r_{ds(on)}$	—	600	ohms
Forward Transfer Admittance (V_{DS} = −10 V, I_D = 2.0 mA, f = 1.0 kHz)		$\|y_{fs}\|$	1000	—	μmho
Input Capacitance (V_{DS} = −10 V, V_{GS} = 0, f = 140 kHz)		C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 140 kHz)		C_{rss}	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = −10 V, f = 140 kHz)		$C_{d(sub)}$	—	4.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay (Figures 5)	I_D = −2.0 mAdc, V_{DS} = −10 Vdc, V_{GS} = −10 V) (See Figure 9, Times Circuit Determined)	t_{d1}	—	45	ns
Rise Time (Figures 6)		t_r	—	65	ns
Turn-Off Delay (Figures 7)		t_{d2}	—	60	ns
Fall Time (Figures 8)		t_f	—	100	ns

FIGURE 1 — FOWARD TRANSFER ADMITTANCE

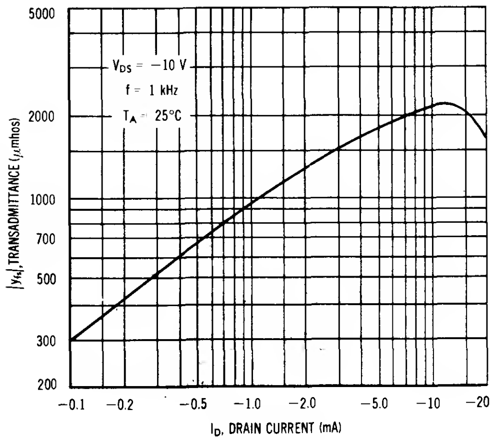


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FIGURE 2 — TRANSFER CHARACTERISTICS

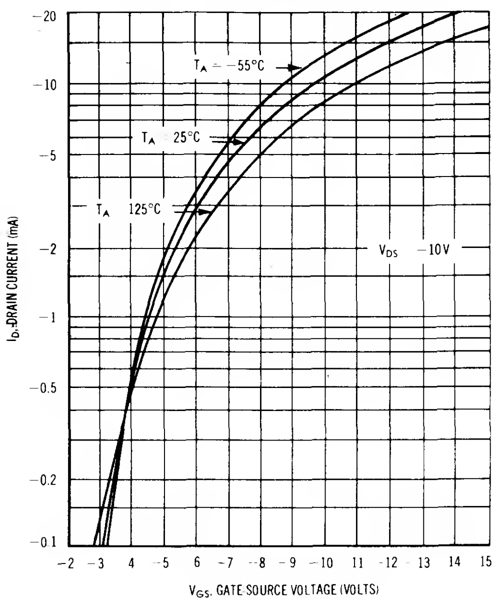


FIGURE 3 — DRAIN-SOURCE "ON" RESISTANCE

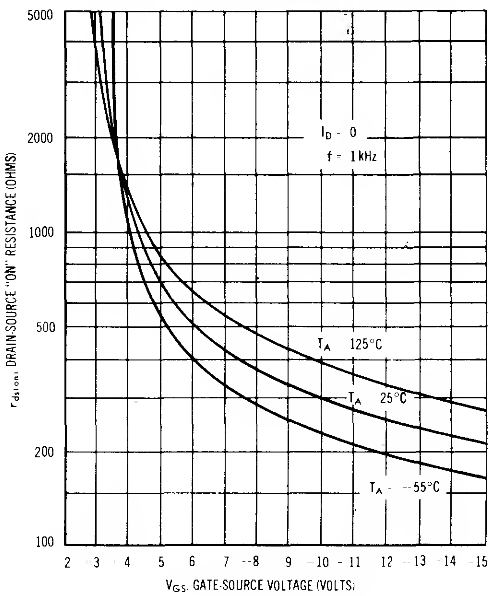
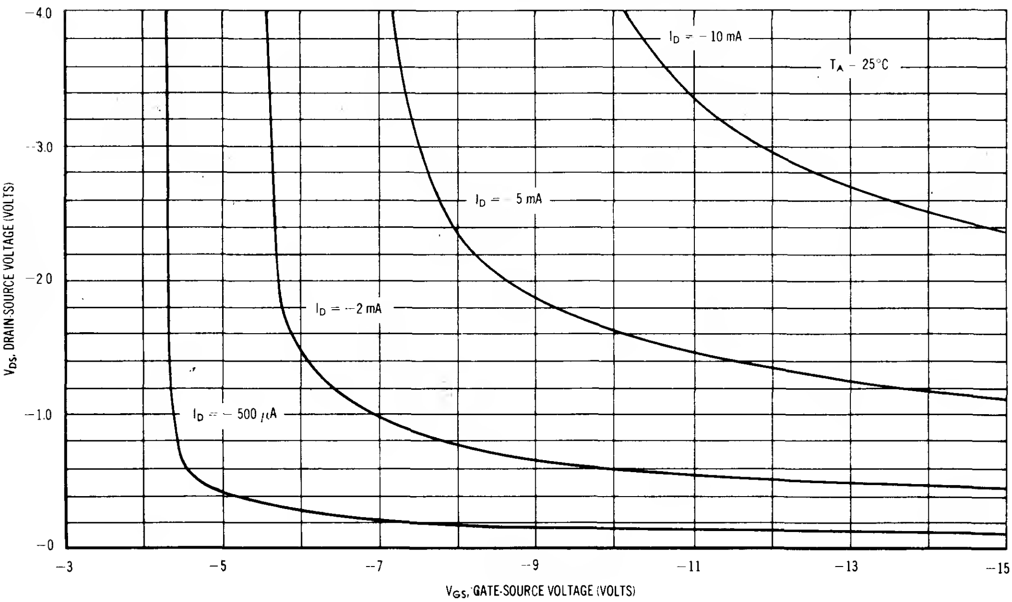


FIGURE 4 — "ON" DRAIN-SOURCE VOLTAGE



SWITCHING CHARACTERISTICS

(T_A = 25°C)

FIGURE 5 — TURN-ON DELAY TIME

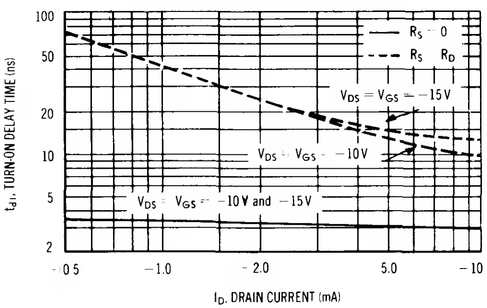


FIGURE 6 — RISE TIME

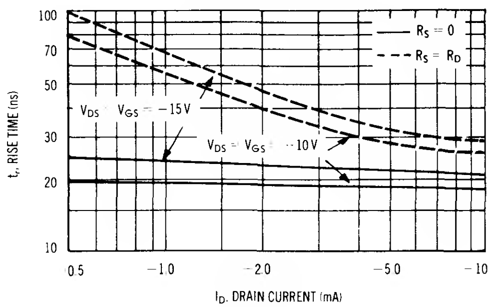


FIGURE 7 — TURN-OFF DELAY TIME

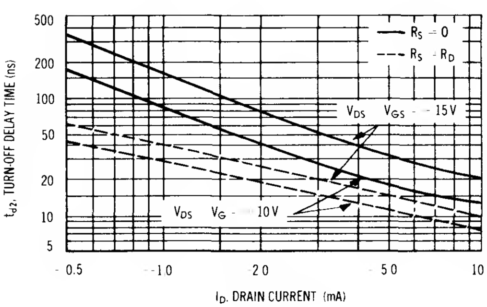


FIGURE 8 — FALL TIME

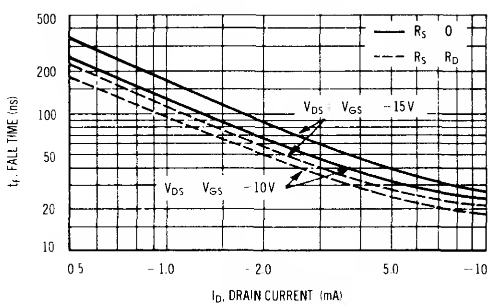
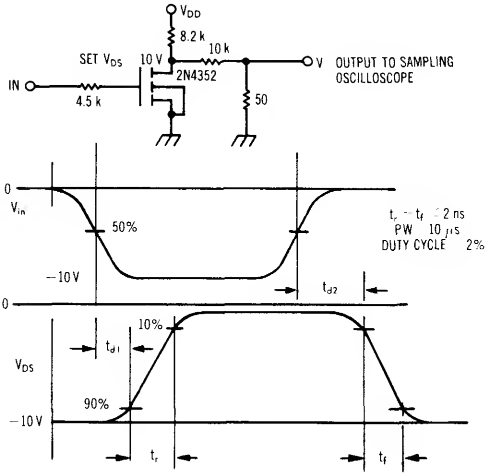


FIGURE 9 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance) (Figure 11). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

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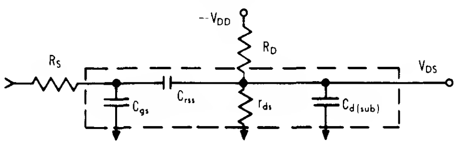
FIGURE 10 — SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



2N4360

CASE 29-02, STYLE 7
TO-92 (TO-226AA)

JFET
LOW-FREQUENCY/LOW-NOISE

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	20	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−55 to +125	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μA)	$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current (V_{GS} = 15)	I_{GSS}	—	10	nA
Gate Source Cutoff Voltage (V_{DS} = −10 V, I_D = 1.0 μA)	$V_{GS(off)}$	0.7	10.0	Vdc
Gate Source Voltage (I_D = 0.3 mA, V_{DS} = −10 V)	V_{GS}	0.4	9.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = −10 V, V_{GS} = 0 V)	I_{DSS}	3.0	30	mA
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance (I_D = 0, V_{GS} = 0, f = 1.0 kHz)	r_{ds}	—	700	Ohms
Forward Transfer Admittance (V_{DS} = −10 V, V_{GS} = 0 V, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	2000	8000	μmhos
Output Admittance (V_{DS} = −10 V, V_{GS} = 0 V, f = 1.0 kHz)	$\lvert y_{os} \rvert$	—	100	μmhos
Common Source Forward Transconductance (V_{DS} = −10 V, V_{GS} = 0 V, f = 1.0 MHz)	$Re(y_{fs})$	1500	—	μmhos
Input Capacitance (V_{DS} = −10 V, f = 1.0 MHz)	C_{iss}	—	20	pF
Reverse Transfer Capacitance (V_{DS} = −10 V, f = 1.0 MHz)	C_{rss}	—	5.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = −10 V, I_D = 1.0 mA, R_G = 1.0 mΩ, f = 100 Hz)	NF	—	5.0	dB

2N4391
2N4392
2N4393

CASE 22-03, STYLE 2
TO-18 (TO-206AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

Refer to MPF4391 for graphs.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 0.1 0.2	nAdc μAdc
Gate Source Voltage (V_{DS} = 20 Vdc, I_D = 1.0 nAdc)	 2N4391 2N4392 2N4393	V_{GS}	 4.0 2.0 0.5	 10 5.0 3.0	Vdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		$V_{GS(f)}$	—	1.0	Vdc
Drain-Cutoff Current (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 7.0 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 5.0 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc, T_A = 150°C) (V_{DS} = 20 Vdc, V_{GS} = 7.0 Vdc, T_A = 150°C) (V_{DS} = 20 Vdc, V_{GS} = 5.0 Vdc, T_A = 150°C)	 2N4391 2N4392 2N4393 2N4391 2N4392 2N4393	$I_{D(off)}$	 — — — — — —	 0.1 0.1 0.1 0.2 0.2 0.2	nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	 2N4391 2N4392 2N4393	I_{DSS}	 50 25 5.0	 150 75 30	mAdc
Drain-Source On-Voltage (I_D = 12 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 3.0 mAdc, V_{GS} = 0)	 2N4391 2N4392 2N4393	$V_{DS(on)}$	 — — —	 0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 2N4391 2N4392 2N4393	$r_{DS(on)}$	 — — —	 30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N4391 2N4392 2N4393	$r_{ds(on)}$	 — — —	 30 60 100	Ohms

*ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	14	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz) (V_{DS} = 0, V_{GS} = 7.0 Vdc, f = 1.0 MHz) (V_{DS} = 0, V_{GS} = 5.0 Vdc, f = 1.0 MHz)	 2N4391 2N4392 2N4393	C_{rss}	 — — —	 3.5 3.5 3.5	pF
SWITCHING CHARACTERISTICS					
Rise Time ($I_{D(on)}$ = 12 mAdc) ($I_{D(on)}$ = 6.0 mAdc) ($I_{D(on)}$ = 3.0 mAdc)	 2N4391 2N4392 2N4393	t_r	 — — —	 5.0 5.0 5.0	ns
Fall Time ($V_{GS(off)}$ = 12 Vdc) ($V_{GS(off)}$ = 7.0 Vdc) ($V_{GS(off)}$ = 5.0 Vdc)	 2N4391 2N4392 2N4393	t_f	 — — —	 15 20 30	ns
Turn-On Time ($I_{D(on)}$ = 12 mAdc) ($I_{D(on)}$ = 6.0 mAdc) ($I_{D(on)}$ = 3.0 mAdc)	 2N4391 2N4392 2N4393	t_{on}	 — — —	 15 15 15	ns
Turn-Off Time ($V_{GS(off)}$ = 12 Vdc) ($V_{GS(off)}$ = 7.0 Vdc) ($V_{GS(off)}$ = 5.0 Vdc)	 2N4391 2N4392 2N4393	t_{off}	 — — —	 20 35 50	ns

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.
*In addition to JEDEC Registered Data.

6

2N4416,A

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Drain-Source Voltage		V_{DS}	30	Vdc
Drain-Gate Voltage	2N4416 2N4416A	V_{DG}	35 30	Vdc
Gate-Source Voltage		V_{GS}	30	Vdc
Gate Current		I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C		P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−65 to +175	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	 2N4416 2N4416A	$V_{(BR)GSS}$	 30 35	 — —	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = +150°C)		I_{GSS}	 — —	 100 200	pAdc
Gate Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 15 Vdc)		$V_{GS(off)}$	—	6.0	Vdc
Gate Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)		V_{GS}	1.0	5.5	Vdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		$V_{GS(f)}$	—	1.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)		I_{DSS}	5.0	15	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{fs}\|$	4500	7500	μmhos
Real Part of Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)		$y_{fs(real)}$	4000	—	μmhos
Real Part of Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)		$y_{is(real)}$	 — —	 100 1000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	50	μmhos
Real Part of Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)		$y_{os(real)}$	 — —	 75 100	μmhos
Imaginary Part of Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)		$y_{is(imag)}$	 — —	 2500 10,000	μmhos
Imaginary Part of Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)		$y_{os(imag)}$	 — —	 1000 4000	μmhos

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	0.8	pF
Common Source Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (Figures 3 and 4)	NF			dB
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, $R_g \approx$ 1000 Ohms, f = 100 MHz)		—	2.0	
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, $R_g \approx$ 1000 Ohms, f = 400 MHz)		—	4.0	
Small-Signal Power Gain Common Source (Figure 1)	G_{ps}			dB
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 100 MHz)		18	—	
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 400 MHz)		10	—	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

POWER GAIN

FIGURE 1 — EFFECTS OF DRAIN CURRENT

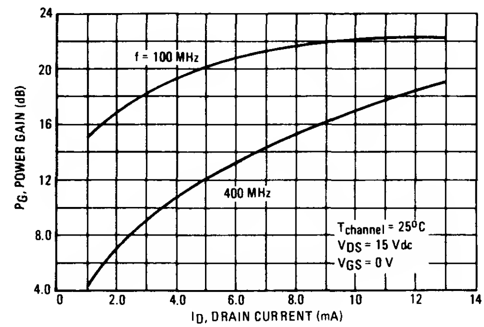
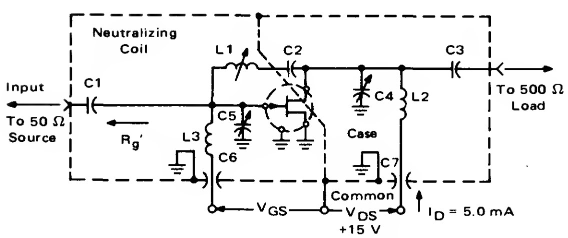


FIGURE 2 — 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



Adjust V_{GS} for I_D = 50 mA
V_{GS} < 0 Volts

NOTE: The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

Reference Designation	VALUE 100 MHz	VALUE 400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1-12 pF	0.8-8.0 pF
C5	1-12 pF	0.8-8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH*	0.2 μH**
L2	0.15 μH*	0.03 μH**
L3	0.14 μH*	0.022 μH**

*L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).

L3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

**L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).

L3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).

NOISE FIGURE

($T_{channel}$ = 25°C)

FIGURE 3 – EFFECTS OF DRAIN-SOURCE VOLTAGE

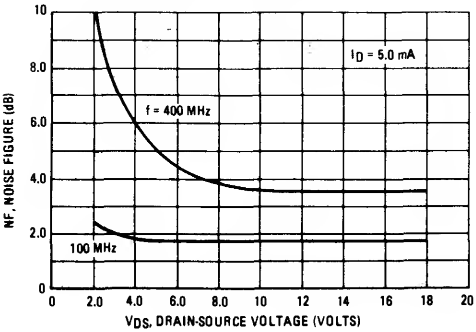
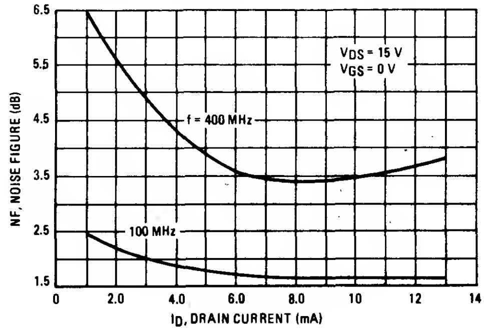
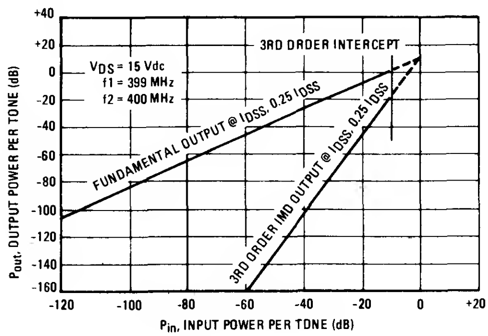


FIGURE 4 – EFFECTS OF DRAIN CURRENT



INTERMODULATION CHARACTERISTICS

FIGURE 5 – THIRD ORDER INTERMODULATION DISTORTION



COMMON SOURCE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

FIGURE 6 – INPUT ADMITTANCE (y_{is})

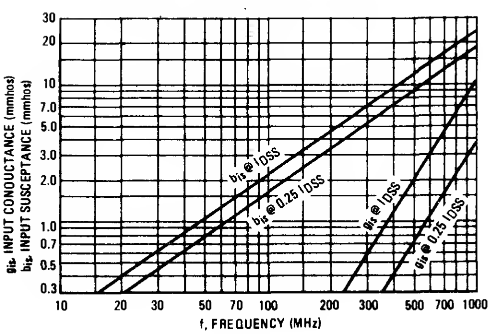


FIGURE 7 – REVERSE TRANSFER ADMITTANCE (y_{rs})

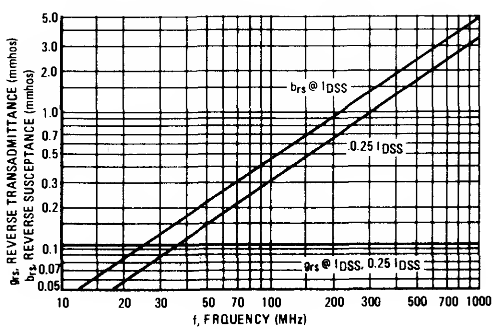


FIGURE 8 – FORWARD TRANSADMITTANCE (y_{fs})

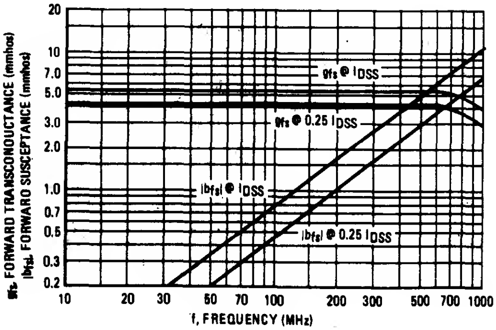
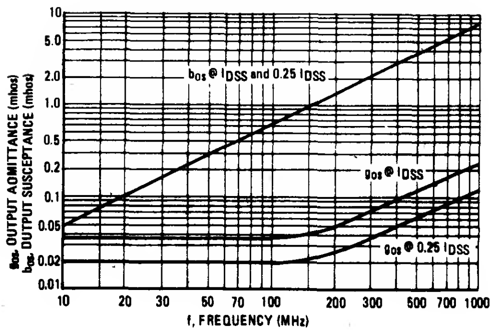


FIGURE 9 – OUTPUT ADMITTANCE (y_{os})



COMMON SOURCE CHARACTERISTICS
S-PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

FIGURE 10 – S_{11s}

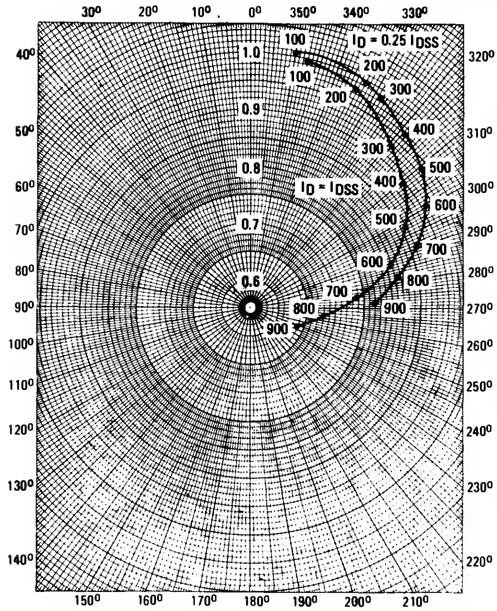
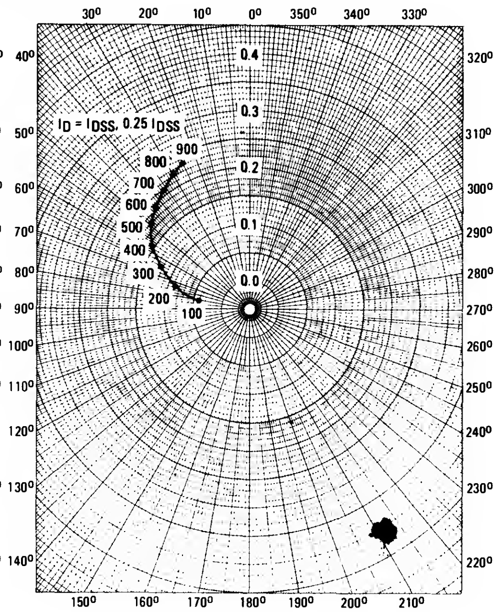


FIGURE 11 – S_{12s}



6

FIGURE 12 – S_{21s}

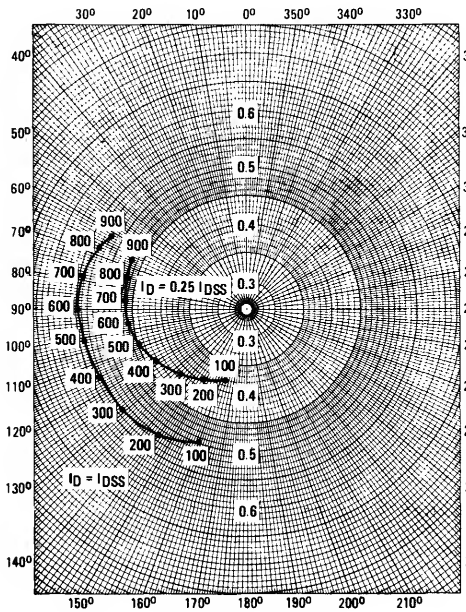
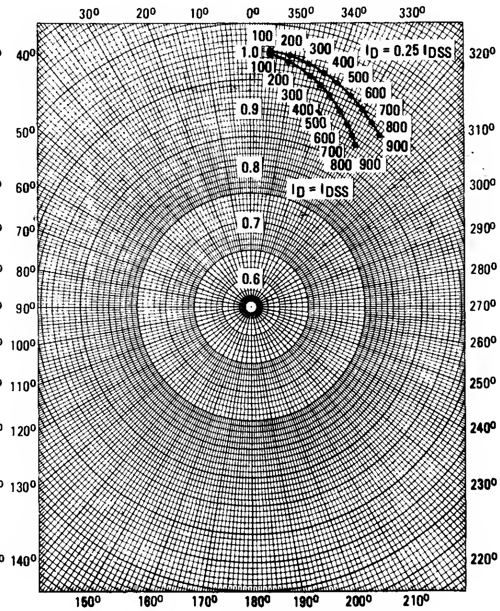


FIGURE 13 – S_{22s}



6

COMMON GATE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

FIGURE 14 – INPUT ADMITTANCE (y_{ig})

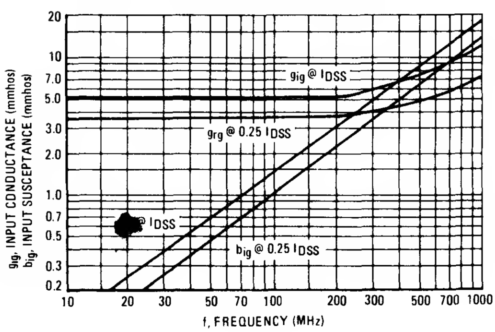


FIGURE 15 – REVERSE TRANSFER ADMITTANCE (y_{rg})

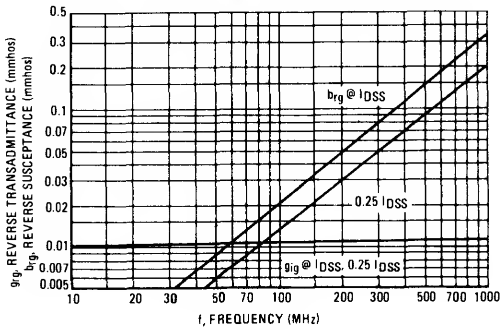


FIGURE 16 – FORWARD TRANSFER ADMITTANCE (y_{fg})

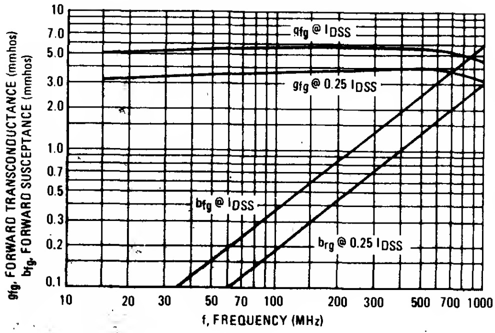
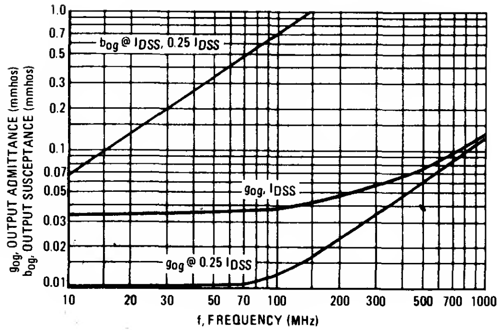


FIGURE 17 – OUTPUT ADMITTANCE (y_{og})



COMMON GATE CHARACTERISTICS

S-PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

FIGURE 18 – S_{11g}

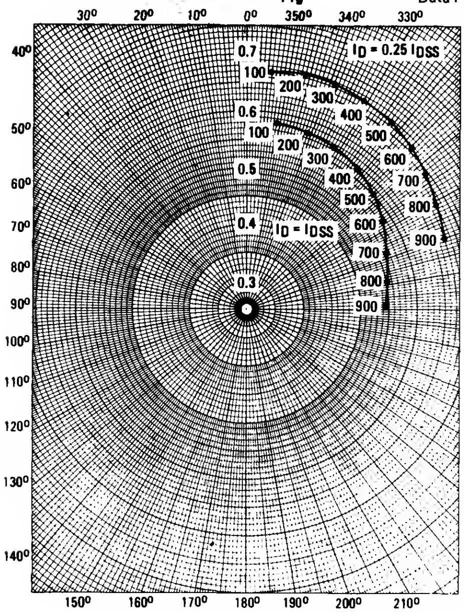


FIGURE 19 – S_{12g}

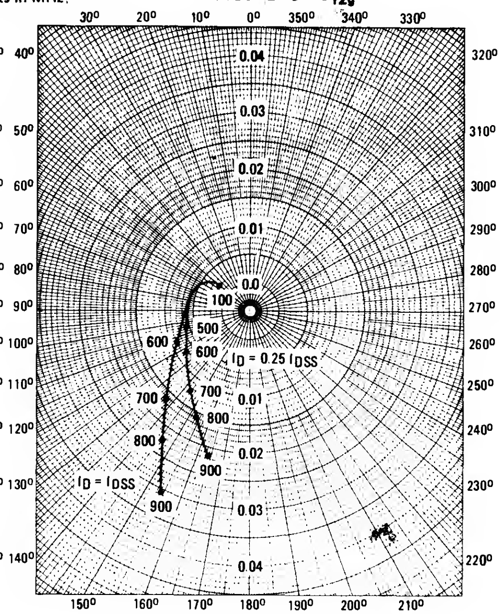


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FIGURE 20 – S_{21g}

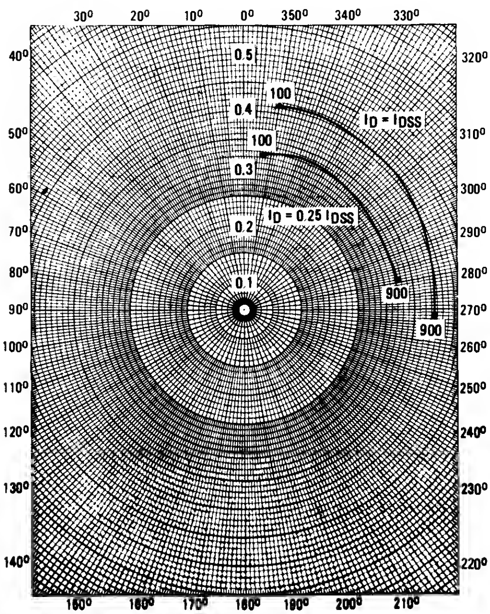
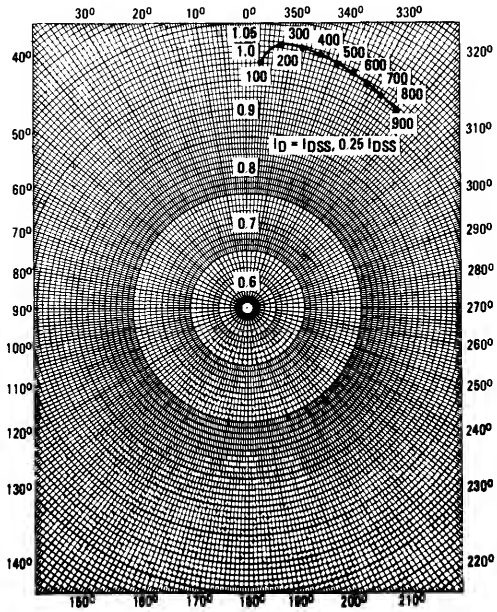


FIGURE 21 – S_{22g}



2N4856,A
thru
2N4861,A

JAN, JTX AVAILABLE
CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	2N4858,A 2N4857,A 2N4858,A	2N4859,A 2N4860,A 2N4861,A	Unit
Drain-Source Voltage	V_{DS}	+40	+30	Vdc
Drain-Gate Voltage	V_{DG}	+40	+30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−40	−30	Vdc
Forward Gate Current	I_{GF}	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 360 2.4		 mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +175		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

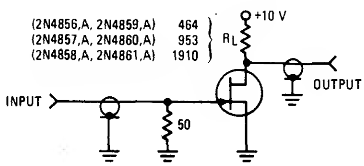
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	 2N4856,A, 2N4857,A, 2N4858,A 2N4859,A, 2N4860,A, 2N4861,A	$V_{(BR)GSS}$	 −40 −30	 — —	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 150°C) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 150°C)	 2N4856,A 2N4857,A, 2N4858,A 2N4859,A, 2N4860,A, 2N4861,A 2N4856,A, 2N4857,A, 2N4858,A 2N4859,A, 2N4860,A, 2N4861,A	I_{GSS}	 — — — —	 0.25 0.25 0.5 0.5	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	 2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	$V_{GS(off)}$	 −4.0 −2.0 −0.8	 −10 −6.0 −4.0	Vdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −10 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −10 Vdc, T_A = 150°C)		$I_{D(off)}$	 — —	 0.25 0.5	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	I_{DSS}	 50 20 8.0	 — 100 80	mAdc
Drain-Source On-Voltage (I_D = 20 mAdc, V_{GS} = 0) (I_D = 10 mAdc, V_{GS} = 0) (I_D = 5.0 mAdc, V_{GS} = 0)	 2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	$V_{DS(on)}$	 — — —	 0.75 0.5 0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	$r_{ds(on)}$	 — — —	 25 40 60	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz)	 2N4856 thru 2N4861 2N4856A thru 2N4861A	C_{iss}	 — —	 18 10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz)	 2N4856 thru 2N4861 2N4856A, 2N4859A 2N4857A, 2N4858A, 2N4860A, 2N4861A	C_{rss}	 — — —	 8.0 4.0 3.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

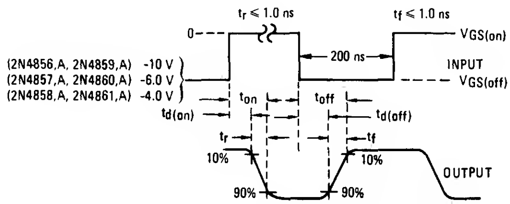
Characteristic			Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS (See Figure 1) (2)						
Turn-On Delay Time	Conditions for 2N4856,A, 2N4859,A:	2N4856, 2N4859	$t_{d(on)}$	—	6.0	ns
		2N4856A, 2N4859A		—	5.0	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc,	2N4857, 2N4860		—	6.0	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc)	2N4857A, 2N4860A		—	6.0	
		2N4858, 2N4861		—	10	
		2N4858A, 2N4861A		—	8.0	
Rise Time	Conditions for 2N4857,A, 2N4860,A:	2N4856,A, 2N4859,A	t_r	—	3.0	ns
		2N4857,A, 2N4860,A		—	4.0	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc,	2N4858, 2N4861		—	10	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −6.0 Vdc)	2N4858A, 2N4861A		—	8.0	
Turn-Off Time		2N4856, 2N4859	t_{off}	—	25	ns
	Conditions for 2N4858,A, 2N4861,A:	2N4856A, 2N4859A		—	20	
		2N4857, 2N4860		—	50	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc,	2N4857A, 2N4860A		—	40	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −4.0 Vdc)	2N4858, 2N4861		—	100	
		2N4858A; 2N4861A		—	80	

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.
(2) The $I_{D(on)}$ values are nominal; exact values vary slightly with transistor parameters.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 ohms, Duty Cycle ≈ 2.0%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ≤ 0.75 ns, R_{in} ≥ 1.0 megohm, C_{in} ≤ 2.5 pF.

2N5245
2N5246
2N5247

CASE 29-02, STYLE 23
TO-92 (TO-226AA)

JFET
HIGH-FREQUENCY
AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	−30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C (Free Air)	P_D	360 2.88	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	500 4.0	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	260	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu A$, $V_{DS} = 0$)		$V_{(BR)GSS}$	−30	—	Vdc
Gate Reverse Current ($V_{GS} = -20$ V, $V_{DS} = 0$)		I_{GSS}	—	−1.0	nA
Gate 1 Leakage Current ($V_{G1S} = -20$ V, $V_{DS} = 0$, $T_A = 100°C$)		I_{G1SS}	—	−0.5	μA
Gate Source Cutoff Voltage ($V_{DS} = 15$ V, $I_D = 10$ mA)	2N5245 2N5246 2N5247	$V_{GS(off)}$	−1.0 −0.5 −1.5	−6.0 −4.0 −8.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 15$ V, $V_{GS} = 0$, Pulsed: See Note 1)	2N5245 2N5246 2N5247	I_{DSS}	5.0 1.5 8.0	15 7.0 24	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 kHz)	2N5245 2N5246 2N5247	$\lvert y_{fs} \rvert$	4500 3000 4500	7500 6000 8000	μmhos
Input Admittance ($V_{DS} = 15$ V, $V_{GS} = 0$)	(100 MHz) (400 MHz)	$Re(y_{is})$	— —	100 1000	μmhos
Output Admittance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 kHz)	2N5245 2N5246 2N5247	$\lvert y_{os} \rvert$	— — —	50 50 70	μmhos
Output Conductance ($V_{DS} = 15$ V, $V_{GS} = 0$)	2N5245 (100 MHz) 2N5246 2N5247 2N5245 (400 MHz) 2N5246 2N5247	$Re(y_{os})$	— — — — — —	75 75 100 100 100 150	μmhos

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Forward Transconductance (V_{DS} = 15 V, V_{GS} = 0, f = 400 MHz)	2N5245 2N5246 2N5247	$Re(y_{fs})$	4000 2500 4000	— — —	µmhos
Input Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 Mhz)		C_{iss}	—	4.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.0	pF
Input Susceptance (V_{DS} = 15 V, V_{GS} = 0)	(100 MHz) (400 MHz)	$I_M(Yis)$	— —	3.0 12.0	mmho
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 V, I_D = 5.0 mA, R'_G = 1.0 kΩ)		NF	— —	2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 V, I_D = 5.0 mA, R'_G = 1.0 kΩ)	2N5245 (100 MHz) 2N5245 (400 MHz)	G_{ps}	18 10	— —	dB
Output Susceptance (V_{DS} = 15 V, V_{GS} = 0)	(100 MHz) (400 MHz)	$I_M(Yos)$	— —	1000 4000	µmho

Note 1: tp = 100 ms, Duty Cycle = 10%.

2N5265 thru 2N5270

CASE 20-05, STYLE 5
TO-72 (TO-206AF)

JFET
GENERAL PURPOSE

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Drain-Gate Voltage	V_{DG}	60	Vdc
Reverse Gate-Source Voltage	V_{GSR}	60	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 10\ \mu$Adc, $V_{DS} = 0$)		$V_{(BR)GSS}$	60	—	Vdc
Gate Reverse Current ($V_{GS} = 30$ Vdc, $V_{DS} = 0$) ($V_{GS} = 30$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)		I_{GSS}	 — —	 2.0 2.0	 nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 1.0\ \mu$Adc)	 2N5265, 2N5266 2N5267, 2N5268 2N5269, 2N5270	$V_{GS(off)}$	 — — —	 3.0 6.0 8.0	Vdc
Gate Source Voltage ($V_{DS} = 15$ Vdc, $I_D = 0.05$ mAdc) ($V_{DS} = 15$ Vdc, $I_D = 0.08$ mAdc) ($V_{DS} = 15$ Vdc, $I_D = 0.15$ mAdc) ($V_{DS} = 15$ Vdc, $I_D = 0.25$ mAdc) ($V_{DS} = 15$ Vdc, $I_D = 0.4$ mAdc) ($V_{DS} = 15$ Vdc, $I_D = 0.7$ mAdc)	 2N5265 2N5266 2N5267 2N5268 2N5269 2N5270	V_{GS}	 0.3 0.4 1.0 1.0 2.0 2.0	 1.5 2.0 4.0 4.0 6.0 6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	 2N5265 2N5266 2N5267 2N5268 2N5269 2N5270	I_{DSS}	 0.5 0.8 1.5 2.5 4.0 7.0	 1.0 1.6 3.0 5.0 8.0 14	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	 2N5265 2N5266 2N5267 2N5268 2N5269 2N5270	$\|y_{fs}\|$	 900 1000 1500 2000 2200 2500	 2700 3000 3500 4000 4500 5000	μmhos
Output Admittance Common Source ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)		$\|y_{os}\|$	—	75	μmhos

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Common Source Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5265 2N5266 2N5267 2N5268 2N5269 2N5270	$Re(y_{fs})$	800 900 1400 1700 1900 2100	— — — — — —	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 M ohm, f = 100 Hz, BW = 1.0 Hz)		NF	—	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	—	115	$nV/\sqrt{Hz}$

6

FIGURE 1–6 TRANSFER CHARACTERISTIC CURVES FOR MIN/MAX I_{DSS} LIMITS

FIGURE 1

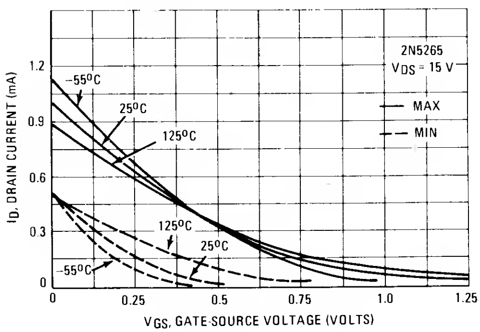


FIGURE 2

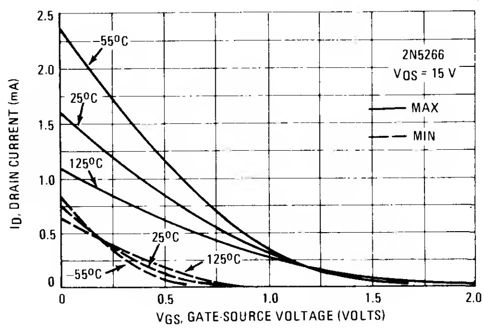


FIGURE 3

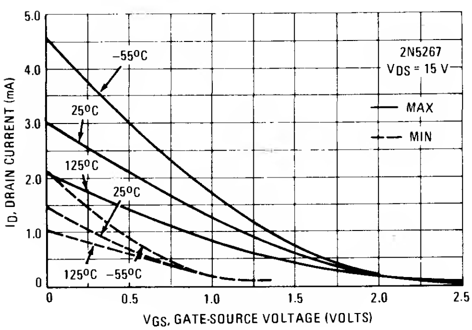


FIGURE 4

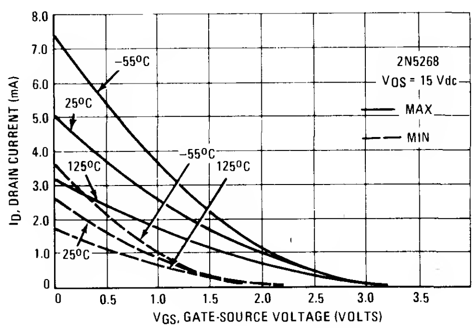


FIGURE 5

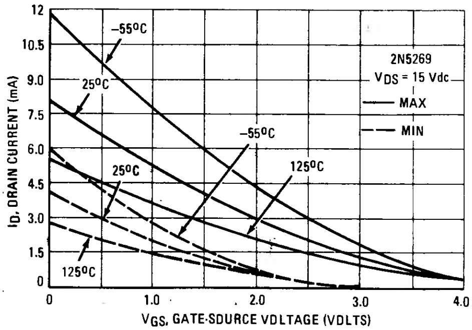
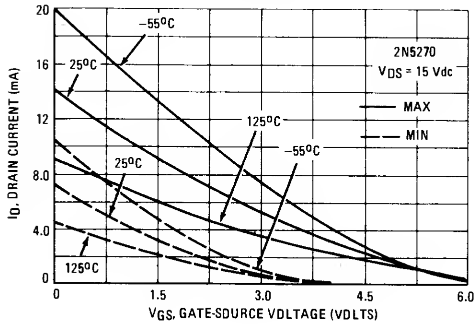


FIGURE 6



FIGURES 7-12 – TYPICAL AND MINIMUM FORWARD TRANSFER ADMITTANCE

FIGURE 7

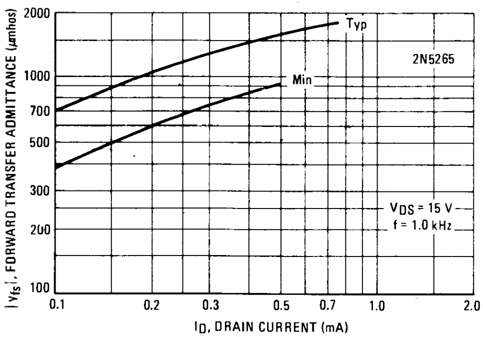


FIGURE 8

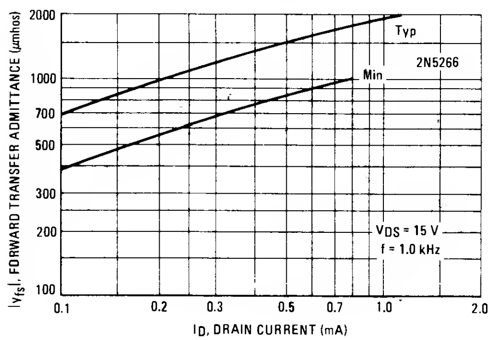


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FIGURE 9

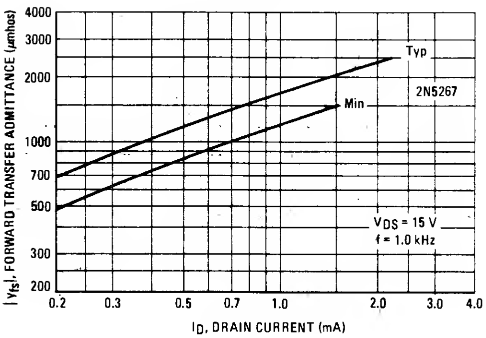


FIGURE 10

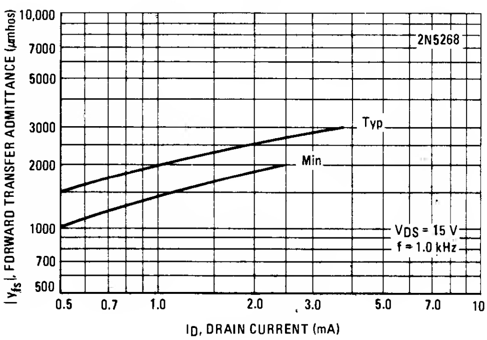


FIGURE 11

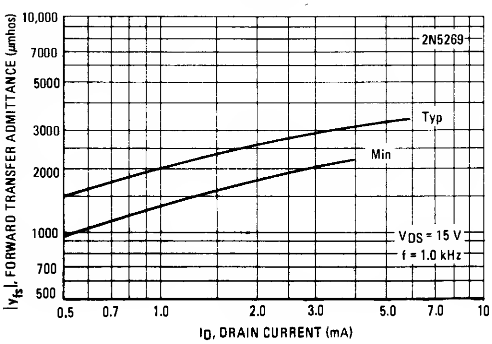
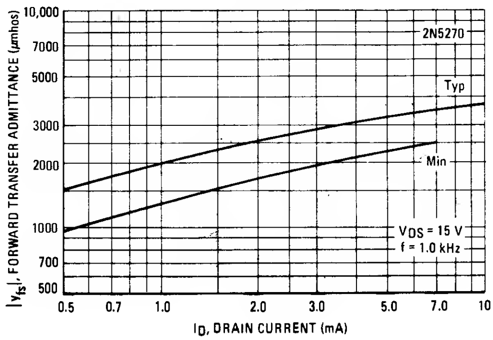


FIGURE 12



TYPICAL CURVES

FIGURE 13 – OUTPUT RESISTANCE versus DRAIN CURRENT

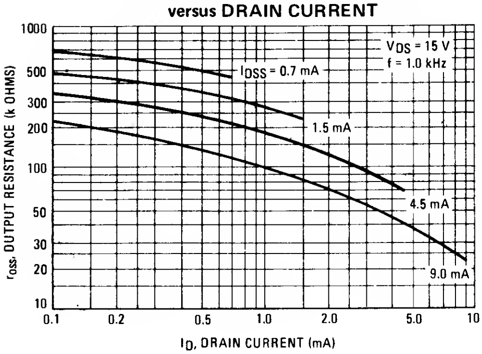


FIGURE 14 – CAPACITANCE versus DRAIN-SOURCE VOLTAGE

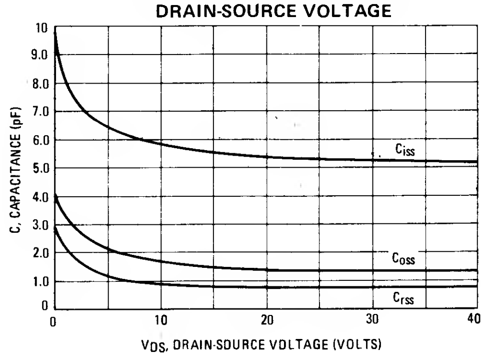


FIGURE 15 – NOISE FIGURE versus FREQUENCY

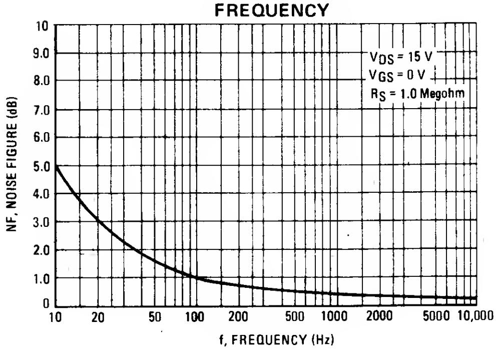


FIGURE 16 – NOISE FIGURE versus SOURCE RESISTANCE

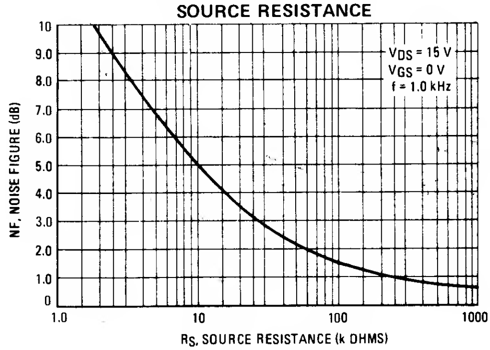


FIGURE 17 – DRAIN CURRENT TEMPERATURE COEFFICIENT versus DRAIN CURRENT

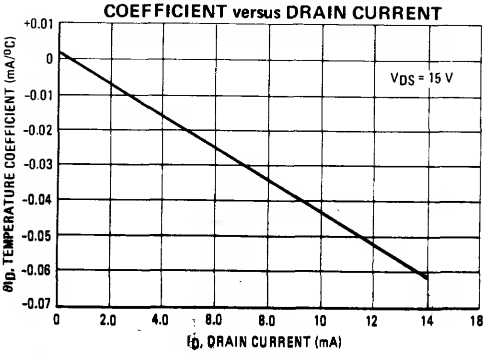
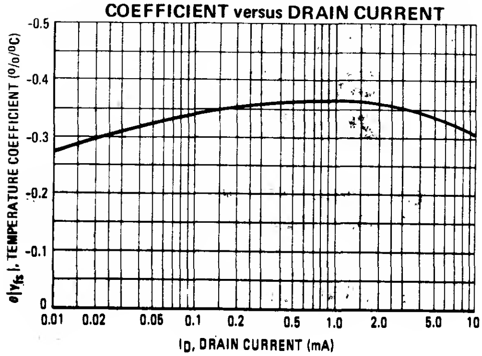


FIGURE 18 – FORWARD TRANSADMITTANCE COEFFICIENT versus DRAIN CURRENT



6

2N5457
2N5458
2N5459

CASE 29-05, STYLE 5
TO-92 (TO-226AA)

JFET
GENERAL PURPOSE

N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	— —	— —	−1.0 −200	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	2N5457 2N5458 2N5459	$V_{GS(off)}$	−0.5 −1.0 −2.0	— — —	−6.0 −7.0 −8.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 100 μAdc) (V_{DS} = 15 Vdc, I_D = 200 μAdc) (V_{DS} = 15 Vdc, I_D = 400 μAdc)	2N5457 2N5458 2N5459	V_{GS}	— — —	−2.5 −3.5 −4.5	— — —	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5457 2N5458 2N5459	I_{DSS}	1.0 2.0 4.0	3.0 6.0 9.0	5.0 9.0 16	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance Common Source* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5457 2N5458 2N5459	$\|y_{fs}\|$	1000 1500 2000	— — —	5000 5500 6000	μmhos
Output Admittance Common Source* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	10	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.5	3.0	pF

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

2N5460 thru 2N5465

CASE 29-02, STYLE 7
TO-92 (TO-226AA)

JFET AMPLIFIER

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	2N5460 2N5461 2N5462	2N5463 2N5464 2N5465	Unit
Drain-Gate Voltage	V_{DG}	40	60	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	60	Vdc
Forward Gate Current	$I_{G(f)}$	10		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82		mW mW/°C
Junction Temperature Range	T_J	−65 to +135		°C
Storage Channel Temperature Range	T_{stg}	−65 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	 2N5460, 2N5461, 2N5462 2N5463, 2N5464, 2N5465	$V_{(BR)GSS}$	 40 60	 — —	 — —	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 30 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C) (V_{GS} = 30 Vdc, V_{DS} = 0, T_A = 100°C)	 2N5460, 2N5461, 2N5462 2N5463, 2N5464, 2N5465 2N5460, 2N5461, 2N5462 2N5463, 2N5464, 2N5465	I_{GSS}	 — — — —	 — — — —	 5.0 5.0 1.0 1.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	 2N5460, 2N5463 2N5461, 2N5464 2N5462, 2N5465	$V_{GS(off)}$	 0.75 1.0 1.8	 — — —	 6.0 7.5 9.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.1 mAdc) (V_{DS} = 15 Vdc, I_D = 0.2 mAdc) (V_{DS} = 15 Vdc, I_D = 0.4 mAdc)	 2N5460, 2N5463 2N5461, 2N5464 2N5462, 2N5465	V_{GS}	 0.5 0.8 1.5	 — — —	 4.0 4.5 6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5460, 2N5463 2N5461, 2N5464 2N5462, 2N5465	I_{DSS}	 1.0 2.0 4.0	 — — —	 5.0 9.0 16	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5460, 2N5463 2N5461, 2N5464 2N5462, 2N5465	$\lvert y_{fs} \rvert$	 1000 1500 2000	 — — —	 4000 5000 6000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\lvert y_{os} \rvert$	—	—	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	5.0	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.0	2.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 1.0 Hz)		NF	—	1.0	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	—	60	115	nV/√Hz

6

DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 1 — $V_{GS(off)}$ = 2.0 VOLTS

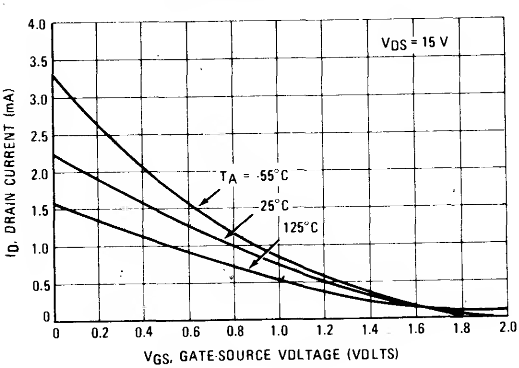


FIGURE 2 — $V_{GS(off)}$ = 4.0 VOLTS

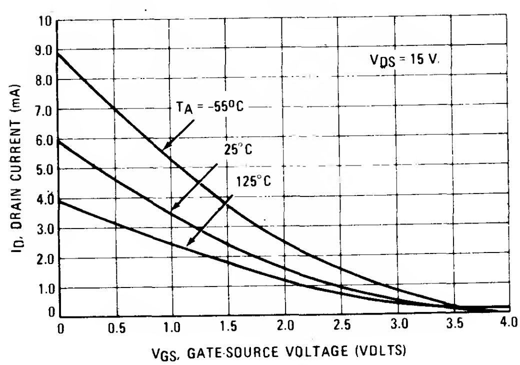
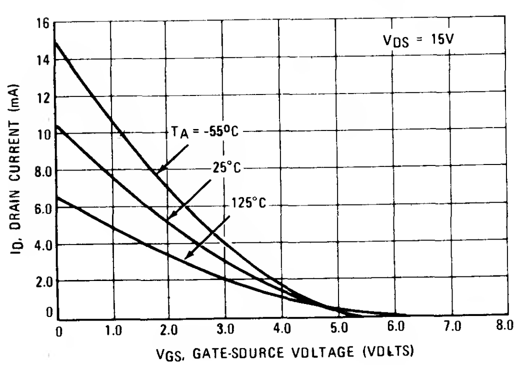


FIGURE 3 — $V_{GS(off)}$ = 5.0 VOLTS



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 4 — $V_{GS(off)}$ = 2.0 VOLTS

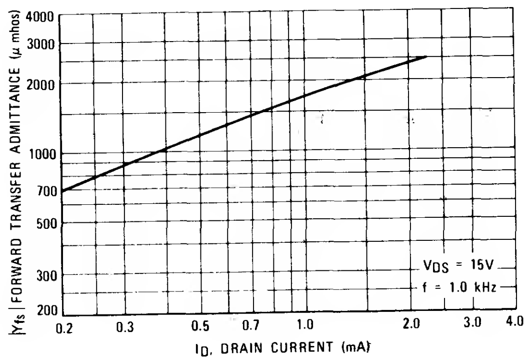


FIGURE 5 — $V_{GS(off)}$ = 4.0 VOLTS

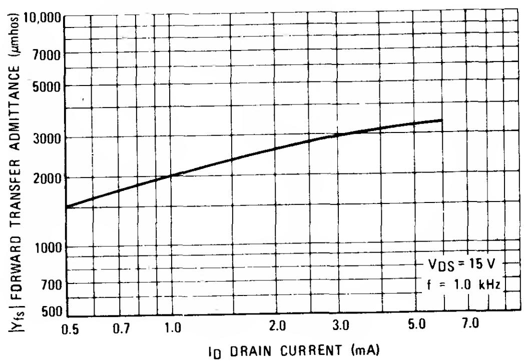


FIGURE 6 — $V_{GS(off)}$ = 5.0 VOLTS

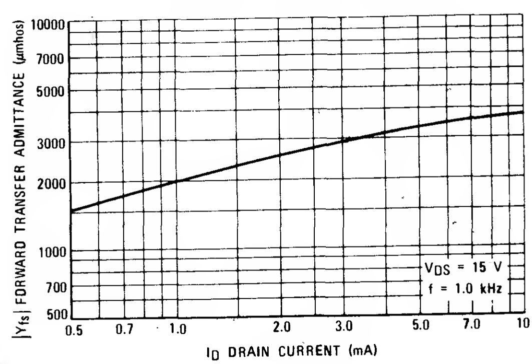


FIGURE 7 – OUTPUT RESISTANCE VERSUS DRAIN CURRENT

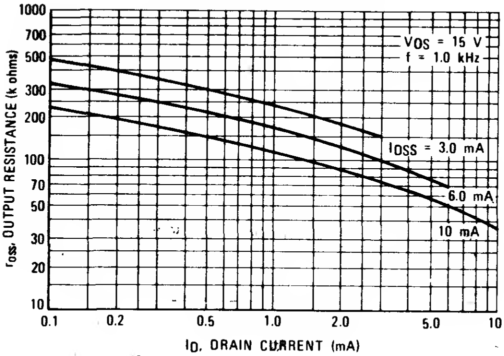


FIGURE 8 – CAPACITANCE VERSUS DRAIN-SOURCE VOLTAGE

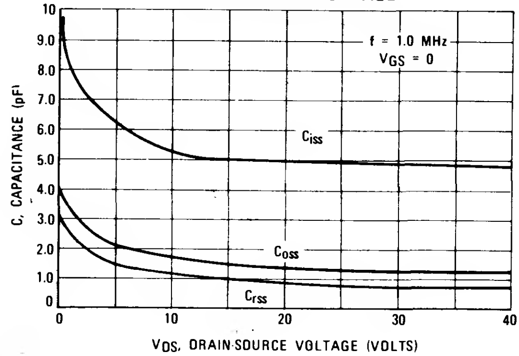


FIGURE 9 – NOISE FIGURE VERSUS FREQUENCY

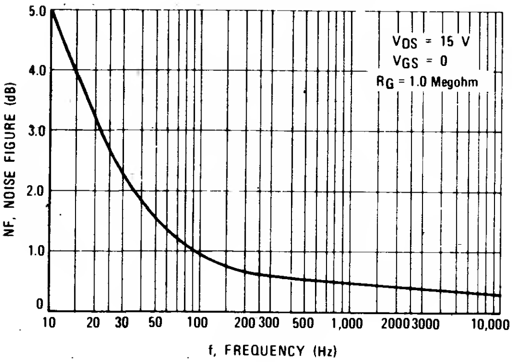


FIGURE 10 – NOISE FIGURE VERSUS SOURCE RESISTANCE

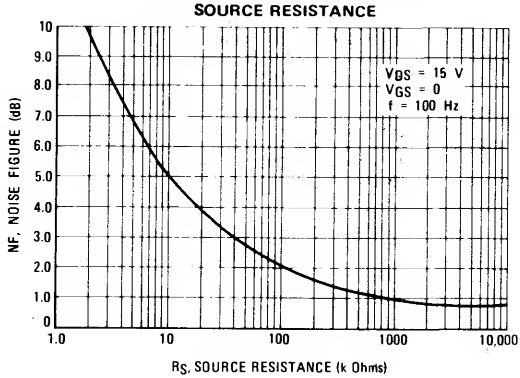
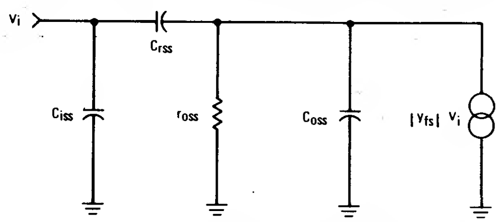


FIGURE 11 – EQUIVALENT LOW FREQUENCY CIRCUIT



Common Source
y Parameters for Frequencies
Below 30 MHz

$y_{is} = j\omega C_{iss}$

$y_{os} = j\omega C_{osp}{}^{*} + 1/r_{oss}$

$y_{fs} = |y_{fs}|$

$y_{rs} = -j\omega C_{rss}$

*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

NOTE:

1 Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%).

6

2N5484 thru 2N5486

CASE 29-05, STYLE 5
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Drain Current	I_D	30	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0) (V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	— —	— —	−1.0 −0.2	nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	2N5484 2N5485 2N5486	$V_{GS(off)}$	−0.3 −0.5 −2.0	— — —	−3.0 −4.0 −6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5484 2N5485 2N5486	I_{DSS}	1.0 4.0 8.0	— — —	5.0 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5484 2N5485 2N5486	$\|y_{fs}\|$	3000 3500 4000	— — —	6000 7000 8000	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5484 2N5485, 2N5486	$Re(y_{is})$	— —	— —	100 1000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5484 2N5485 2N5486	$\|y_{os}\|$	— — —	— — —	50 60 75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5484 2N5485, 2N5486	$Re(y_{os})$	— —	— —	75 100	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5484 2N5485 2N5486	$Re(y_{fs})$	2500 3000 3500	— — —	— — —	μmhos

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	—	1.0	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	—	2.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure		NF				dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)			—	—	2.5	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 100 MHz)	2N5484		—	—	3.0	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 200 MHz)	2N5484		—	4.0	—	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 100 MHz)	2N5485, 2N5486		—	—	2.0	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 400 MHz)	2N5485, 2N5486		—	—	4.0	
Common Source Power Gain		G_{ps}				dB
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 100 MHz)	2N5484		16	—	25	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 200 MHz)	2N5484		—	14	—	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz)	2N5485, 2N5486		18	—	30	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz)	2N5485, 2N5486		10	—	20	

6

2N5555

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

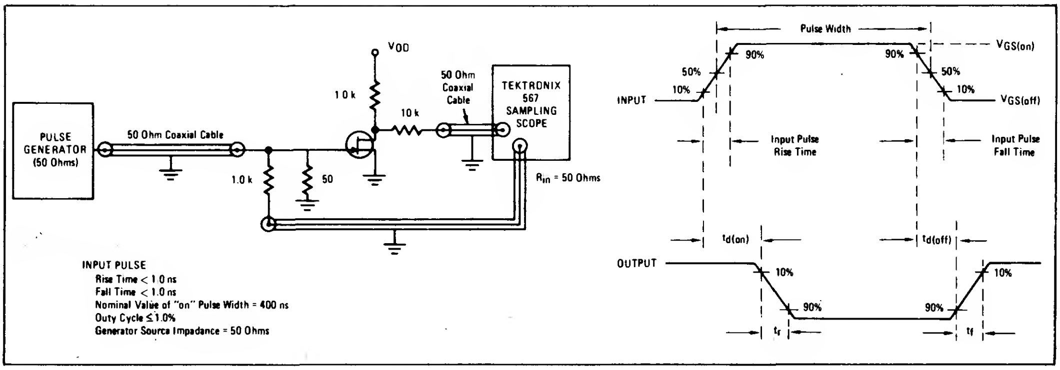
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	−65 to +150	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 10\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$)		I_{GSS}	—	1.0	nAdc
Drain Cutoff Current ($V_{DS} = 12$ Vdc, $V_{GS} = -10$ V) ($V_{DS} = 12$ Vdc, $V_{GS} = -10$ V, $T_A = 100°C$)		$I_{D(off)}$	 — —	 10 2.0	nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)		I_{DSS}	15	—	mAdc
Gate-Source Forward Voltage ($I_{G(f)} = 1.0$ mAdc, $V_{DS} = 0$)		$V_{GS(f)}$	—	1.0	Vdc
Drain-Source On-Voltage ($I_D = 7.0$ mAdc, $V_{GS} = 0$)		$V_{DS(on)}$	—	1.5	Vdc
Static Drain-Source On Resistance ($I_D = 0.1$ mAdc, $V_{GS} = 0$)		$r_{DS(on)}$	—	150	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)		$r_{ds(on)}$	—	150	Ohms
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 10$ Vdc, f = 1.0 MHz)		C_{rss}	—	1.2	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay Time	($V_{DD} = 10$ Vdc, $I_{D(on)} = 7.0$ mAdc, $V_{GS(on)} = 0$, $V_{GS(off)} = -10$ Vdc) (See Figure 1)	$t_{d(on)}$	—	5.0	ns
Rise Time		t_r	—	5.0	ns
Turn-Off Delay Time	($V_{DD} = 10$ Vdc, $I_{D(on)} = 7.0$ mAdc, $V_{GS(on)} = 0$, $V_{GS(off)} = -10$ Vdc) (See Figure 1)	$t_{d(off)}$	—	15	ns
Fall Time		t_f	—	10	ns

*Pulse Test: Pulse Width < 300 μs, Duty Cycle < 3.0%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



6

2N5638
2N5639
2N5640

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	−65 to +150	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 1.0 1.0	 nAdc μAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −12 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −6.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −12 Vdc, T_A = 100°C) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc, T_A = 100°C) (V_{DS} = 15 Vdc, V_{GS} = −6.0 Vdc, T_A = 100°C)	 2N5638 2N5639 2N5640 2N5638 2N5639 2N5640	$I_{D(off)}$	 — — — — — —	 1.0 1.0 1.0 1.0 1.0 1.0	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	 2N5638 2N5639 2N5640	I_{DSS}	 50 25 5.0	 — — —	mAdc
Drain-Source On-Voltage (I_D = 12 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 3.0 mAdc, V_{GS} = 0)	 2N5638 2N5639 2N5640	$V_{DS(on)}$	 — — —	 0.5 0.5 0.5	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 2N5638 2N5639 2N5640	$r_{DS(on)}$	 — — —	 30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N5638 2N5639 2N5640	$r_{ds(on)}$	 — — —	 30 60 100	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{iss}	—	10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{rss}	—	4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic				Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS							
Turn-On Delay Time	V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc, R_G' = 50 ohms	$I_{D(on)}$ = 12 mAdc	2N5638	$t_{d(on)}$	—	4.0	ns
		6.0 mAdc	2N5639		—	6.0	
		3.0 mAdc	2N5640		—	8.0	
Rise Time		$I_{D(on)}$ = 12 mAdc	2N5638	t_r	—	5.0	ns
		6.0 mAdc	2N5639		—	8.0	
		3.0 mAdc	2N5640		—	10	
Turn-Off Delay Time		$I_{D(on)}$ = 12 mAdc	2N5638	$t_{d(off)}$	—	5.0	ns
		6.0 mAdc	2N5639		—	10	
		3.0 mAdc	2N5640		—	15	
Fall Time		$I_{D(on)}$ = 12 mAdc	2N5638	t_f	—	10	ns
		6.0 mAdc	2N5639		—	20	
		3.0 mAdc	2N5640		—	30	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

6

2N5653
2N5654

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

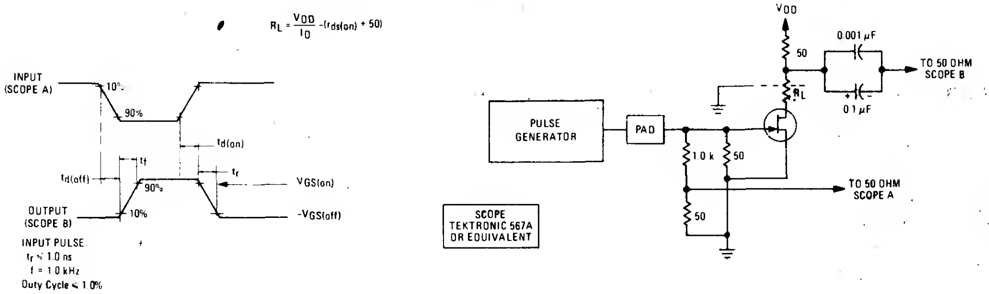
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 1.0 1.0	 nAdc μAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −12 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −12 Vdc, T_A = 100°C) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc, T_A = 100°C)	 2N5653 2N5654 2N5653 2N5654	$I_{D(off)}$	 — — — —	 1.0 1.0 1.0 1.0	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	 2N5653 2N5654	I_{DSS}	 40 15	 — —	mAdc
Drain-Source On-Voltage (I_D = 10 mAdc, V_{GS} = 0) (I_D = 5.0 mAdc, V_{GS} = 0)	 2N5653 2N5654	$V_{DS(on)}$	 — —	 0.75 0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 1.0 mAdc) (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N5653 2N5654 2N5653 2N5654	$r_{ds(on)}$	 — — — —	 50 100 50 100	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{iss}	—	10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz) (V_{DS} = 0, V_{GS} = −8.0 Vdc, f = 1.0 MHz)	 2N5653 2N5653	C_{rss}	 — —	 3.5 3.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	Test Condition for 2N5653: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0,	2N5653	$t_{d(on)}$	—	4.0	ns
	$V_{GS(off)}$ = −12 Vdc,	2N5654		—	6.0	
Rise Time	$I_{D(on)}$ = 10 mAdc,	2N5653	t_r	—	5.0	ns
	R_G' = 50 Ohms)	2N5654		—	8.0	
Turn-Off Delay Time	Test Condition for 2N5654: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0,	2N5653	$t_{d(off)}$	—	5.0	ns
	$V_{GS(off)}$ = −12 Vdc,	2N5654		—	10	
Fall Time	$I_{D(on)}$ = 5.0 mAdc,	2N5653	t_f	—	10	ns
	R_G' = 50 Ohms) (Figure 1)	2N5654		—	20	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



2N5668
2N5669
2N5670

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

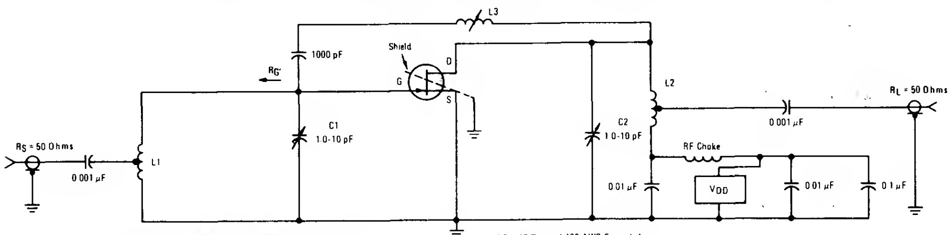
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 2.0 2.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 2N5668 2N5669 2N5670	$V_{GS(off)}$	 0.2 1.0 2.0	 — — —	 4.0 6.0 8.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N5668 2N5669 2N5670	I_{DSS}	 1.0 4.0 8.0	 — — —	 5.0 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5668 2N5669 2N5670	$\|y_{fs}\|$	 1500 2000 3000	 — — —	 6500 6500 7500	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		$Re(y_{is})$	—	125	800	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5668 2N5669 2N5670	$\|y_{os}\|$	 — — —	 — — —	 20 50 75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 2N5668 2N5669 2N5670	$Re(y_{os})$	 — — —	 10 25 35	 50 100 150	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 2N5668 2N5669 2N5670	$Re(y_{fs})$	 1000 1600 2500	 — — —	 — — —	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	4.7	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.0	3.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	1.4	4.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz at R_G' = 1.0 k ohm)	NF	—	—	2.5	dB
Common Source Power Gain (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	G_{ps}	16	—	—	dB

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

FIGURE 1 — 100 MHz, POWER GAIN AND NOISE FIGURE TEST CIRCUIT



L1 ≈ 8.5 Turns of #14 AWG Tinned Copper, Dia ≈ 3/8", ≈ 0.9" Long Tapped at ≈ 2 1/2 Turns (adjust to give R_G = 1.0 k ohm), Parallel Resistance = 40 k ohms, tunes at ≈ 8.0 pF

L2 ≈ 13.5 Turns #16 AWG Tinned Copper, Dia ≈ 3/8", ≈ 1.2" Long Tapped at ≈ 5 Turns, Parallel Resistance = 40 k ohms, tunes at ≈ 4.0 pF

L3 ≈ 17 Turns of #28 AWG Enameled Copper Wire, Close Wound on 9/32" Ceramic Form, Tuning Provided by a Powdered Iron Slug

6

2N6659
2N6660
2N6661
MPF6659
MPF6660
MPF6661

2N6659,60,61
CASE 79-02, STYLE 6
TO-39 (TO-205AD)

MPF6659,60,61
CASE 29-03, STYLE 22
TO-226AE

TMOS
SWITCHING TRANSISTOR

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	2N6659 MPF6659	2N6660 MPF6660	2N6661 MPF6661	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}	± 30			Vdc
Drain Current — Continuous (1) Pulsed (2)	I_D I_{DM}	2.0 3.0			Adc
		2N6659 2N6660 2N6661	MPF6659 MPF6660 MPF6661		
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	6.25 50	2.5 20		Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	— —	1.0 8.0		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current (V_{GS} = 15 V, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	2N6659, MPF6659 2N6660, MPF6660 2N6661, MPF6661	$V_{(BR)DSX}$	35 60 90	— — —	— — —	Vdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(Th)}$	0.8	1.4	2.0	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 1.0 A)	2N6659, MPF6659 2N6660, MPF6660 2N6661, MPF6661	$V_{DS(on)}$	— — —	— — —	1.8 3.0 4.0	Vdc
(V_{GS} = 5.0 V, I_D = 0.3 A)	2N6659, MPF6659 2N6660, MPF6660 2N6661, MPF6661		— — —	0.8 0.9 0.9	1.5 1.5 1.6	
Static Drain-Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	2N6659, MPF6659 2N6660, MPF6660 2N6661, MPF6661	$r_{DS(on)}$	— — —	— — —	1.8 3.0 4.0	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	30	50	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	3.6	10	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	20	40	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{fs}	170	—	—	mmhos

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS(1)					
Rise Time	t_r	—	—	5.0	ns
Fall Time	t_f	—	—	5.0	ns
Turn-On Time	t_{on}	—	—	5.0	ns
Turn-Off Time	t_{off}	—	—	5.0	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

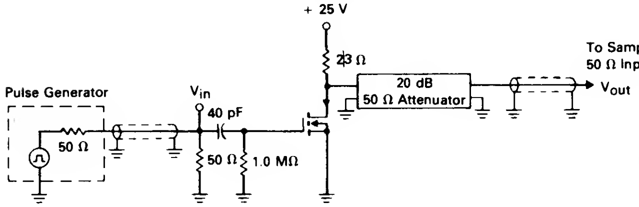


FIGURE 2 — SWITCHING WAVEFORMS

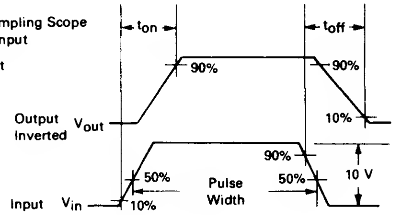


FIGURE 3 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

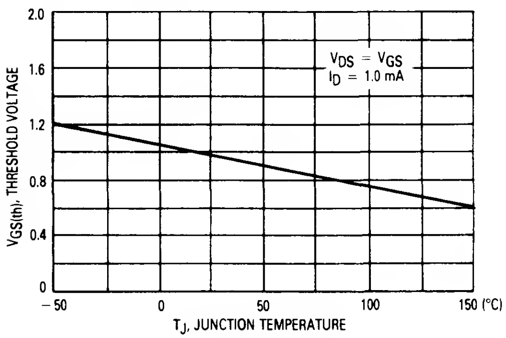


FIGURE 4 — ON-REGION CHARACTERISTICS

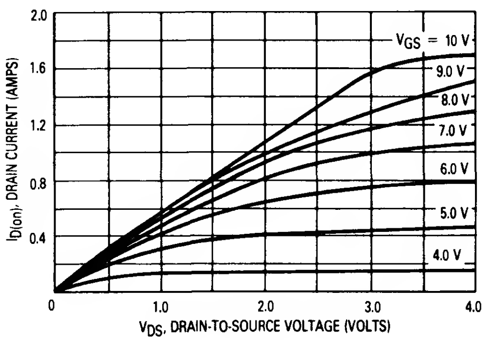


FIGURE 5 — OUTPUT CHARACTERISTICS

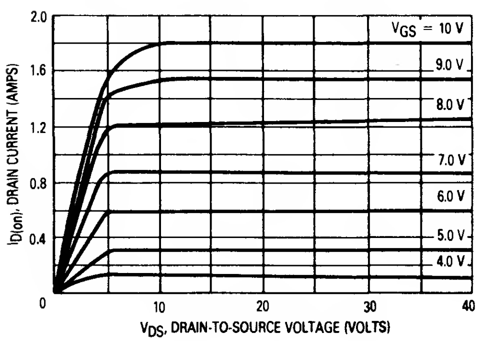


FIGURE 6 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE

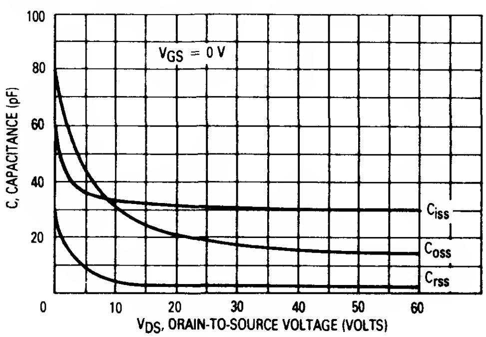


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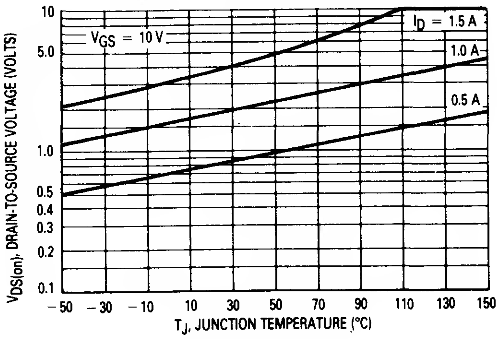
FIGURE 7 — ON-VOLTAGE versus TEMPERATURE



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3N128

CASE 20-03, STYLE 7
TO-72 (TO-206AF)

MOSFET AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+20	Vdc
Drain-Gate Voltage	V_{DG}	+20	Vdc
Gate-Source Voltage	V_{GS}	±10	Vdc
Drain Current	I_D	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	330 2.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage(1) (I_G = −10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	−50	—	Vdc
Gate Reverse Current (V_{GS} = −8.0 Vdc, V_{DS} = 0) (V_{GS} = −8.0 Vdc, V_{DS} = 0, T_A = 125°C)	I_{GSS}	 — —	 0.05 5.0	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 50 μAdc)	$V_{GS(off)}$	−0.5	−8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(2) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	25	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 kHz)	$\|Y_{fs}\|$	5000	12,000	μmhos
Input Admittance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	$Re(y_{is})$	—	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	$Re(y_{os})$	—	500	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	$Re(y_{fs})$	5000	—	μmhos
Input Capacitance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 MHz)	C_{rss}	0.05	0.35	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	NF	—	5.0	dB
Power Gain (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	P_G	13.5	23	dB

(1) Caution Destructive Test, can damage gate oxide beyond operation.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

TYPICAL CHARACTERISTICS
(T_A = 25°C)

FIGURE 1 – DRAIN CHARACTERISTICS

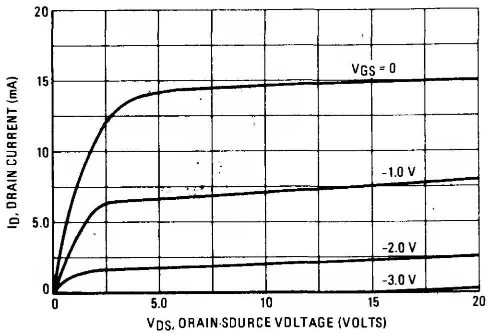
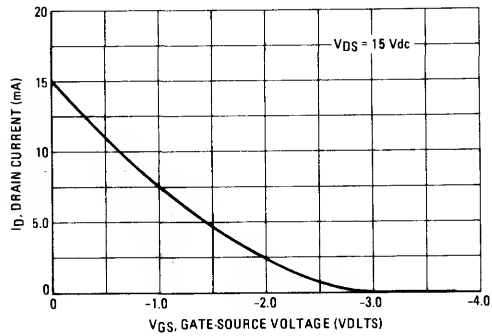


FIGURE 2 – TRANSFER CHARACTERISTICS



TYPICAL 1 kHz DRAIN CHARACTERISTICS
(T_A = 25°C, V_{DS} = 15 Vdc, f = 1.0 kHz)

FIGURE 3 – FORWARD TRANSADMITTANCE versus GATE BIAS VOLTAGE

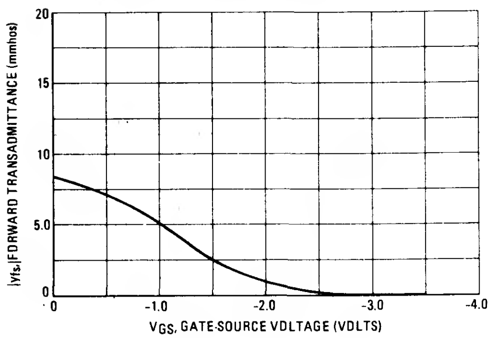
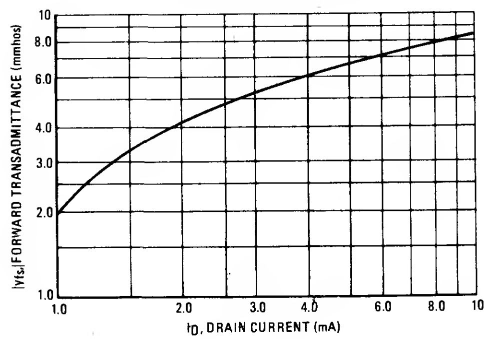


FIGURE 4 – FORWARD TRANSADMITTANCE versus DRAIN CURRENT



TYPICAL 200 MHz COMMON-SOURCE ADMITTANCE CHARACTERISTICS
(T_A = 25°C, V_{DS} = 15 Vdc, f = 200 MHz)

FIGURE 5 – INPUT ADMITTANCE (y_{is}) COMPONENTS

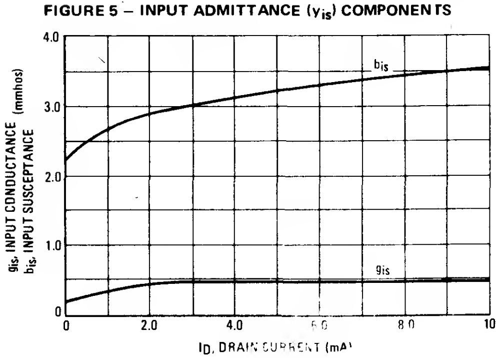


FIGURE 6 – FORWARD TRANSADMITTANCE (y_{fs}) COMPONENTS

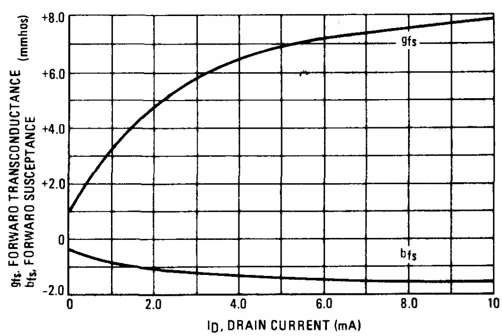


FIGURE 7 – REVERSE TRANSADMITTANCE (y_{rs}) COMPONENTS

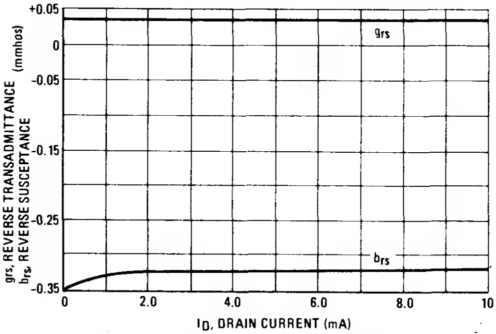


FIGURE 8 – OUTPUT ADMITTANCE (y_{os}) COMPONENTS

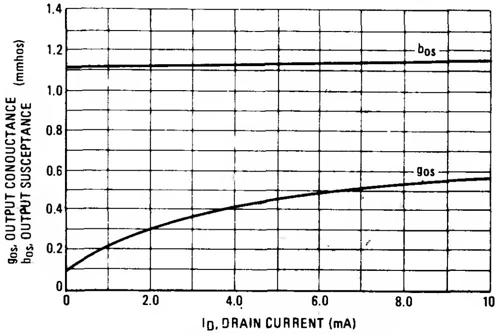


FIGURE 9 – POWER GAIN AND NOISE FIGURE versus DRAIN CURRENT

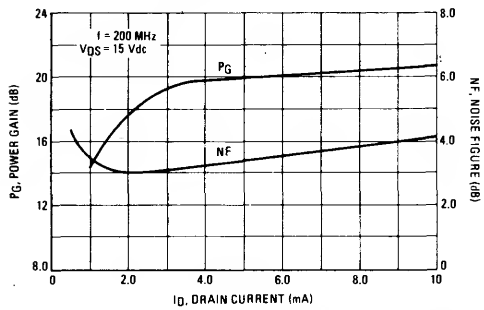


FIGURE 10 – POWER GAIN AND NOISE FIGURE versus DRAIN VOLTAGE

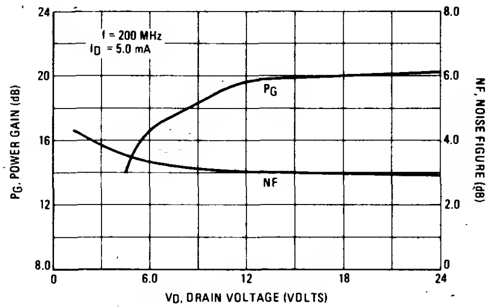


FIGURE 11 – THIRD ORDER INTERMODULATION DISTORTION

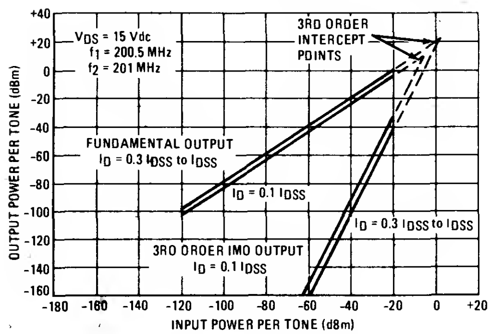
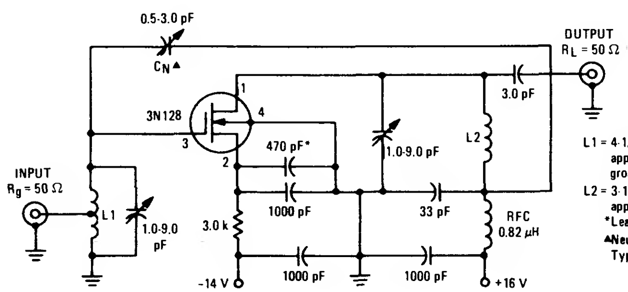


Figure 11 shows the typical third order intermodulation distortion (IMD) performance of the 3N128 at 200 MHz.

Both fundamental output and third order IMD output characteristics are plotted. The curves have been extrapolated to show the third order intermodulation output intercept point.

Performance for drain currents from I_{DSS} to 0.1 I_{DSS}, is given. The power gain and noise figure test amplifier shown in Figure 12 was used to generate the IMD data.

FIGURE 12 – POWER GAIN, NOISE FIGURE AND INTERMODULATION DISTORTION TEST CIRCUIT



L1 = 4-1/2 turns #20 AWG wire, 3/16" diameter, approximately 1/2" long, tapped 1 turn from ground end.
L2 = 3-1/2 turns #20 AWG wire, 3/8" diametar, approximately 1/2" long
*Leadless-type disc capacitor
▲Neutralization fixed for a Transistor having a Typical value of C_{rss} (0.13 pF)

6

3N155
3N156

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOSFET SWITCHING

P-CHANNEL — ENHANCEMENT

Refer to 3N157 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±35	Vdc
Drain-Gate Voltage	V_{DG}	±50	Vdc
Gate-Source Voltage	V_{GS}	±50	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Channel Temperature Range	T_{stg}	−65 to +175	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($I_D = -10\ \mu$Adc, $V_G = V_S = 0$)	$V_{(BR)DSX}$	−35	—	—	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = -10$ Vdc, $V_{GS} = 0$) ($V_{DS} = -10$ Vdc, $V_{GS} = 0$, $T_A = 125°C$)	I_{DSS}	— —	— —	−1.0 −1000	nAdc
Gate Reverse Current ($V_{GS} = +50$ Vdc, $V_{DS} = 0$) ($V_{GS} = +25$ Vdc, $V_{DS} = 0$)	I_{GSS}	— —	— —	+1000 +10	pAdc
Resistance Drain Source ($I_D = 0$, $V_{GS} = 0$)	$r_{DS(off)}$	$1 \times 10^{+10}$	—	—	Ohms
Resistance Gate Source Input ($V_{GS} = -25$ Vdc)	R_{GS}	—	$1 \times 10^{+16}$	—	Ohms
Gate Forward Leakage Current ($V_{GS} = -50$ Vdc, $V_{DS} = 0$) ($V_{GS} = -25$ Vdc, $V_{DS} = 0$)	$I_{G(f)}$	— —	— —	−1000 −10	pAdc
ON CHARACTERISTICS					
Gate Threshold Voltage ($V_{DS} = -10$ Vdc, $I_D = -10\ \mu$Adc)	$V_{GS(Th)}$	−1.5	—	−3.2	Vdc
Drain-Source On-Voltage ($I_D = -2.0$ mAdc, $V_{GS} = -10$ Vdc)	$V_{DS(on)}$	—	—	−1.0	Vdc
Static Drain-Source On Resistance ($I_D = 0$ mAdc, $V_{GS} = -10$ Vdc)	$r_{DS(on)}$	—	—	600	Ohms
On-State Drain Current ($V_{DS} = -15$ Vdc, $V_{GS} = -10$ Vdc)	$I_{D(on)}$	−5.0	—	—	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source Resistance ($V_{GS} = -10$ Vdc, $I_D = 0$, f = 1.0 kHz) ($V_{GS} = -15$ Vdc, $I_D = 0$, f = 1.0 kHz)	$r_{ds(on)}$	— —	— —	400 350	Ohms
Forward Transfer Admittance ($V_{DS} = -15$ Vdc, $I_D = -2.0$ mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	1000	—	4000	µmhos
Input Capacitance ($V_{DS} = -15$ Vdc, $V_{GS} = -10$ Vdc, f = 140 kHz)	C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, f = 140 kHz)	C_{rss}	—	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)} = -10$ Vdc, f = 140 kHz)	$C_{d(sub)}$	4.0	—	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay ($V_{DD} = -10$ Vdc, $I_{D(on)} = -2.0$ mAdc, $V_{GS(on)} = -10$ Vdc, $V_{GS(off)} = 0$)	t_d	—	—	45	µs
Rise Time	t_r	—	—	65	ns
Turn-Off Delay	t_s	—	—	60	ns
Fall Time	t_f	—	—	100	ns

3N157
3N158

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOSFET
AMPLIFIER AND SWITCHING

P-CHANNEL — ENHANCEMENT

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage*	V_{DS}	±35	Vdc
Drain-Gate Voltage*	V_{DG}	±50	Vdc
Gate-Source Voltage*	V_{GS}	±50	Vdc
Drain Current*	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C*	P_D	300 1.7	mW mW/°C
Junction Temperature Range*	T_J	−65 to +175	°C
Storage Channel Temperature Range*	T_{stg}	−65 to +175	°C

*JEDEC Registered Limits

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = −10 μAdc, V_G = V_S = 0)		$V_{(BR)DSX}$	−35	—	—	Vdc
Zero-Gate-Voltage Drain Current (V_{DS} = −15 Vdc, V_{GS} = 0) (V_{DS} = −35 Vdc, V_{GS} = 0)		I_{DSS}	— —	— —	−1.0 −10	nAdc μAdc
Gate Reverse Current* (V_{GS} = +25 Vdc, V_{DS} = 0) (V_{GS} = +50 Vdc, V_{DS} = 0)		I_{GSS}	— —	— —	+10 +10	pAdc nAdc
Input Resistance (V_{GS} = −25 Vdc)		R_{GS}	—	$1 \times 10^{+12}$	—	Ohms
Gate Source Voltage* (V_{DS} = −15 Vdc, I_D = −0.5 mAdc)	3N157 3N158	V_{GS}	−1.5 −3.0	— —	−5.5 −7.0	Vdc
Gate Forward Current* (V_{GS} = −25 Vdc, V_{DS} = 0) (V_{GS} = −50 Vdc, V_{DS} = 0) (V_{GS} = −25 Vdc, V_{DS} = 0, T_A = +55°C) (V_{GS} = −50 Vdc, V_{DS} = 0, T_A = +55°C)		$I_{G(f)}$	— — — —	— — — —	−10 −1.0 −10 −1.0	pAdc nAdc nAdc μAdc
ON CHARACTERISTICS						
Gate Threshold Voltage* (V_{DS} = −15 Vdc, I_D = −10 μAdc)	3N157 3N158	$V_{GS(Th)}$	−1.5 −3.0	— —	−3.2 −5.0	Vdc
On-State Drain Current* (V_{DS} = −15 Vdc, V_{GS} = −10 Vdc)		$I_{D(on)}$	−5.0	—	—	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance* (V_{DS} = −15 Vdc, I_D = −2.0 mAdc, f = 1.0 kHz)		$\|Y_{fs}\|$	1000	—	4000	μmhos
Output Admittance* (V_{DS} = −15 Vdc, I_D = −2.0 mAdc, f = 1.0 kHz)		$\|Y_{os}\|$	—	—	60	μmhos
Input Capacitance* (V_{DS} = −15 Vdc, V_{GS} = 0, f = 140 kHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance* (V_{DS} = −15 Vdc, V_{GS} = 0, f = 140 kHz)		C_{rss}	—	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = −10 Vdc, f = 140 kHz)		$C_{d(sub)}$	—	—	4.0	pF
Noise Voltage (R_S = 0, BW = 1.0 Hz, V_{DS} = −15 Vdc, I_D = −2.0 mAdc, f = 100 Hz) (R_S = 0, BW = 1.0 Hz, V_{DS} = −15 Vdc, I_D = −2.0 mAdc, f = 1.0 kHz)		e_n	 — —	 300 120	 — 500	$NV/\sqrt{Hz}$

*JEDEC Registered Limits

6

FIGURE 1 – FORWARD TRANSCONDUCTANCE

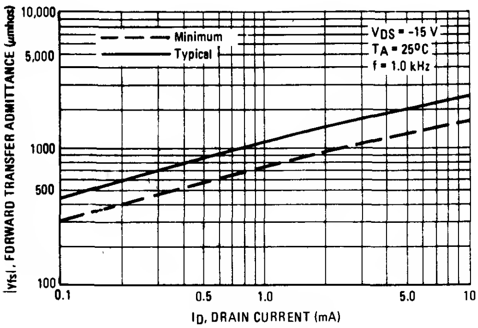


FIGURE 2 – OUTPUT TRANSCONDUCTANCE

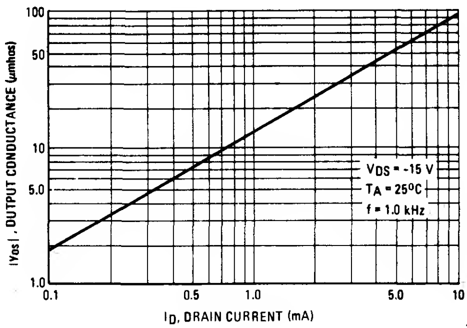


FIGURE 3 – FORWARD TRANSCONDUCTANCE versus TEMPERATURE

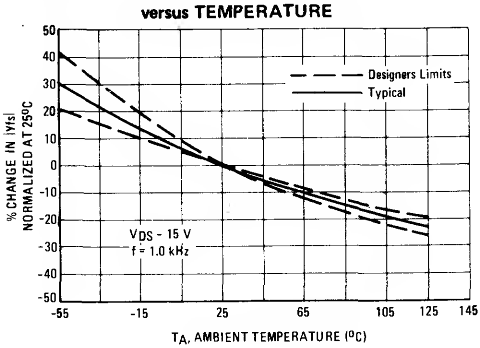


FIGURE 4 – BIAS CURVE

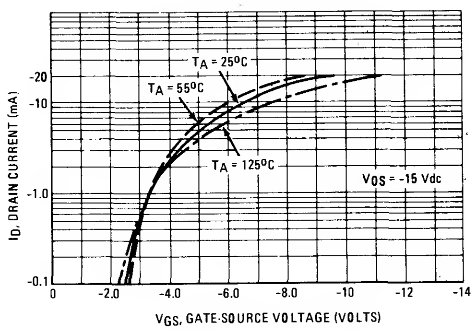


FIGURE 5 – "ON" DRAIN-SOURCE VOLTAGE

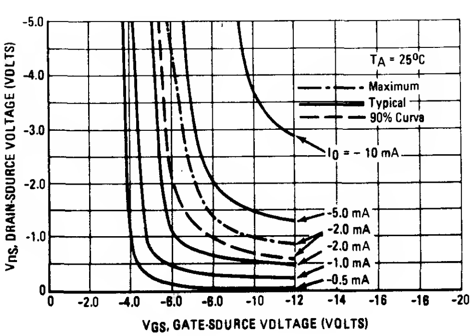
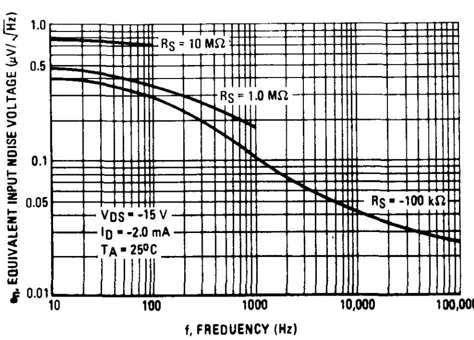


FIGURE 6 – EQUIVALENT INPUT NOISE VOLTAGE



SWITCHING CHARACTERISTICS

(T_A = 25°C)

FIGURE 7 – TURN-ON DELAY TIME

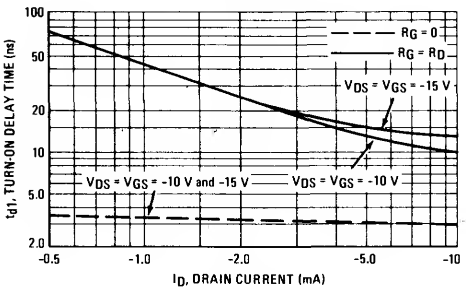


FIGURE 8 – RISE TIME

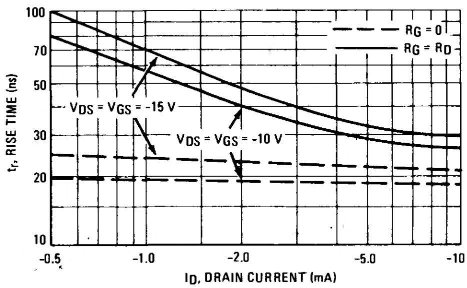


FIGURE 9 – TURN-OFF DELAY TIME

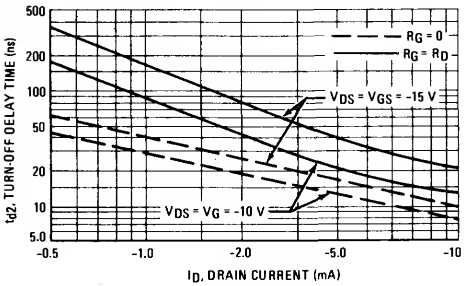


FIGURE 10 – FALL TIME

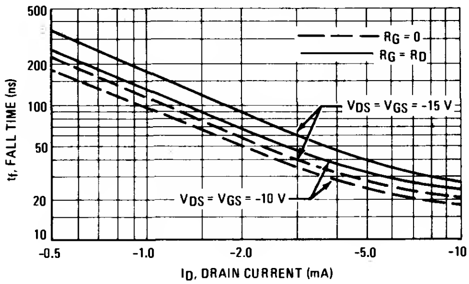


FIGURE 11 – SWITCHING CIRCUIT and WAVEFORMS

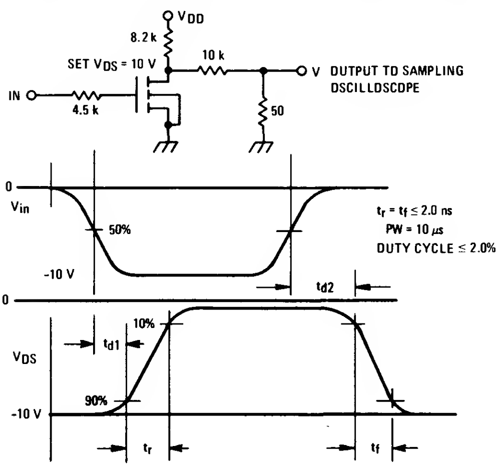
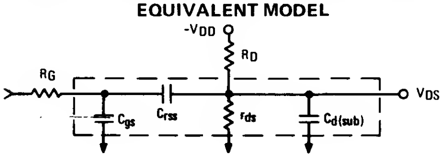


FIGURE 12 – SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



The switching characteristics shown above were measured in a test circuit similar to Figure 11. At the beginning of the switching interval, the gate voltage is at ground and the gate source capacitance (C_{gs} • C_{rss} • C_{rss}) has no charge. The drain voltage is at V_{DD} and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

During the turn-on interval C_{gs} is charged to V_{GS} (the input voltage) through R_G (generator impedance) (Figure 12). C_{rss} must be discharged to V_{GS} • $V_{D(on)}$ through R_G and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 5) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where R_G • 0 and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with R_G • R_D simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with R_G • 0 simulates a low source impedance drive such as might occur in complementary logic circuits.

6

3N169
3N170
3N171

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOSFET
SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to 2N4351 for graphs.

MAXIMUM RATINGS

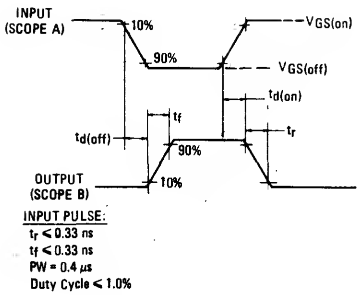
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	±35	Vdc
Gate-Source Voltage	V_{GS}	±35	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	800 4.56	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

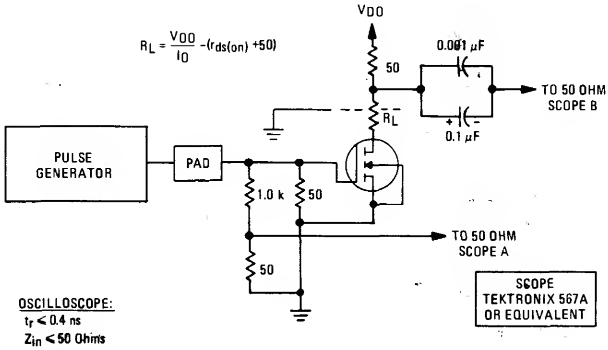
6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{GS} = 0)		$V_{(BR)DSX}$	25	—	Vdc
Zero-Gate-Voltage Drain Current (V_{DS} = 10 Vdc, V_{GS} = 0) (V_{DS} = 10 Vdc, V_{GS} = 0, T_A = 125°C)		I_{DSS}	 — —	 10 1.0	 nAdc μAdc
Gate Reverse Current (V_{GS} = −35 Vdc, V_{DS} = 0) (V_{GS} = −35 Vdc, V_{DS} = 0, T_A = 125°C)		I_{GSS}	 — —	 10 100	pAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 10 μAdc)	 3N169 3N170 3N171	$V_{GS(Th)}$	 0.5 1.0 1.5	 1.5 2.0 3.0	Vdc
Drain-Source On-Voltage (I_D = 10 mAdc, V_{GS} = 10 Vdc)		$V_{DS(on)}$	—	2.0	Vdc
On-State Drain Current (V_{GS} = 10 Vdc, V_{DS} = 10 Vdc)		$I_{D(on)}$	10	—	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = 10 Vdc, I_D = 0, f = 1.0 kHz)		$r_{ds(on)}$	—	200	Ohms
Forward Transfer Admittance (V_{DS} = 10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)		$\|y_{fs}\|$	1000	—	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = 10 Vdc, f = 1.0 MHz)		$C_{d(sub)}$	—	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay Time	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = 10 Vdc, $V_{GS(off)}$ = 0, R_G' = 50 Ohms) See Figure 1	$t_{d(on)}$	—	3.0	ns
Rise Time		t_r	—	10	ns
Turn-Off Delay Time		$t_{d(off)}$	—	3.0	ns
Fall Time		t_f	—	15	ns

FIGURE 1 — SWITCHING TIME TEST CIRCUIT





3N201
3N202
3N203

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE MOSFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to MPF201 for additional graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30	Vdc
Drain Current	I_D	50	mAdc
Gate Current	I_{G1} I_{G2}	±10 ±10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 8.0	Watt mW/°C
Lead Temperature	T_L	300	°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Channel Temperature Range	T_{stg}	−65 to +175	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

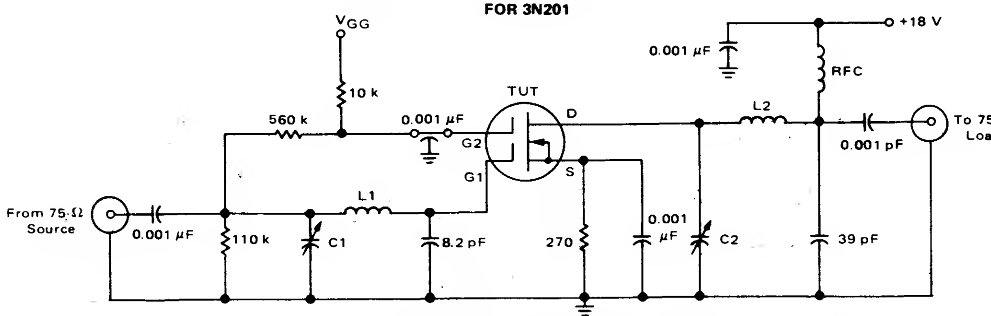
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1S} = V_{G2S} = −5.0 Vdc)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage(1) (I_{G1} = ±10 mAdc, V_{G2S} = V_{DS} = 0)	$V_{(BR)G1SO}$	±6.0	±12	±30	Vdc
Gate 2-Source Breakdown Voltage(1) (I_{G2} = ±10 mAdc, V_{G1S} = V_{DS} = 0)	$V_{(BR)G2SO}$	±6.0	±12	±30	Vdc
Gate 1 Leakage Current (V_{G1S} = ±5.0 Vdc, V_{G2S} = V_{DS} = 0) (V_{G1S} = −5.0 Vdc, V_{G2S} = V_{DS} = 0, T_A = 150°C)	I_{G1SS}	 — —	 ±.040 —	 ±10 −10	 nAdc μAdc
Gate 2 Leakage Current (V_{G2S} = ±5.0 Vdc, V_{G1S} = V_{DS} = 0) (V_{G2S} = −5.0 Vdc, V_{G1S} = V_{DS} = 0, T_A = 150°C)	I_{G2SS}	 — —	 ±.050 —	 ±10 −10	 nAdc μAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 20 μAdc)	$V_{G1S(off)}$	−0.5	−1.5	−5.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 20 μAdc)	$V_{G2S(off)}$	−0.2	−1.4	−5.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(2) (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc) 3N201,3N202 3N203	I_{DSS}	 6.0 3.0	 13 11	 30 15	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(3) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, V_{G1S} = 0, f = 1.0 kHz) 3N201,3N202 3N203	$\|Y_{fs}\|$	 8.0 7.0	 12.8 12.5	 20 15	mmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{iss}	—	3.3	—	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{rss}	0.005	0.014	0.03	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{oss}	—	1.7	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1) 3N201 (V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3) 3N203	NF	 — —	 1.8 5.3	 4.5 6.0	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common Source Power Gain		G_{ps}				dB
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	3N201		15	20	25	
(V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3)	3N203		20	25	30	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz) (Figure 2)	3N202	G_c(5)	15	19	25	
Bandwidth		BW				MHz
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	3N201		5.0	—	9.0	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz) (Figure 2)	3N202		4.5	—	7.5	
(V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3)	3N203		3.0	—	6.0	
Gain Control Gate-Supply Voltage(4)		$V_{GG(GC)}$				Vdc
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 200 MHz) (Figure 1)	3N201		0	−1.0	−3.0	
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 45 MHz) (Figure 3)	3N203		0	−0.6	−3.0	

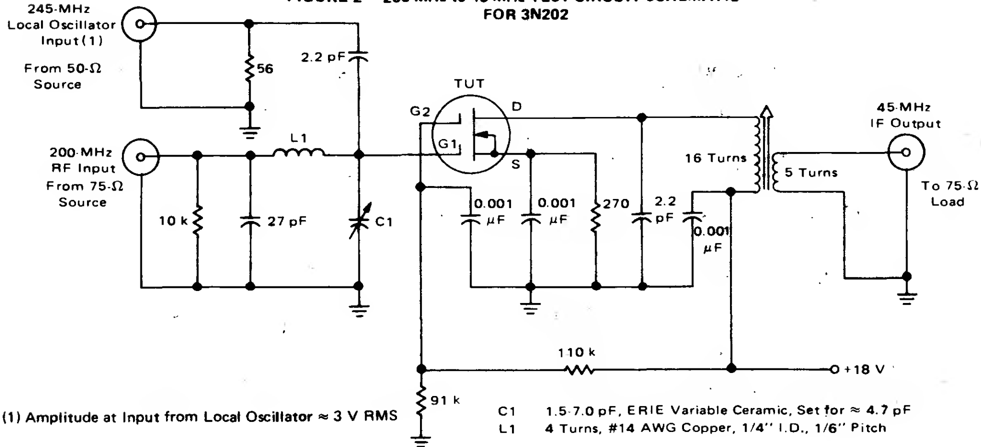
(1) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage limiting network is functioning properly.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
(3) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.
(4) ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7.0 volts (3N201) and V_{GG} = 6.0 volts (3N203).
(5) Power Gain Conversion

FIGURE 1 — 200-MHz TEST CIRCUIT SCHEMATIC FOR 3N201



C1 4.0-30 pF, ERIE Variable Ceramic, Set for ≈ 22 pF
C2 4.0-30 pF, ERIE Variable Ceramic, Set for ≈ 10 pF
L1 4 Turns, #14 AWG Cooper, 1/4" I.D., 1/6" Pitch
L2 3 Turns, #14 AWG Cooper, 1/4" I.D., 1/8" Pitch
RFC DELEVAN No. 153712, 1.0 μH

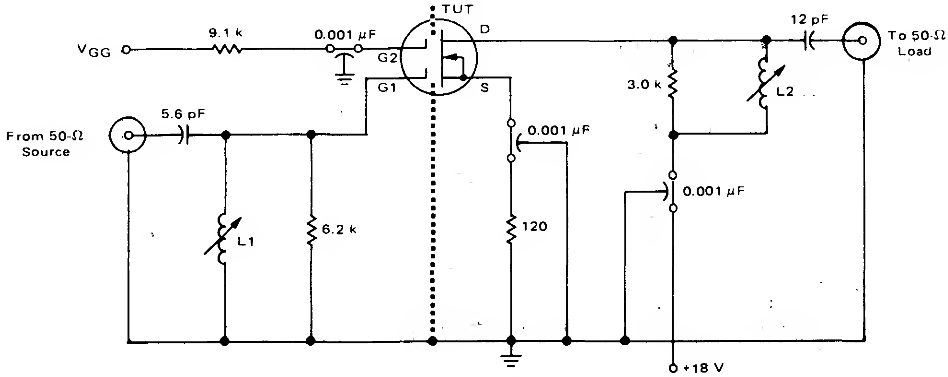
FIGURE 2 — 200-MHz-to-45-MHz TEST CIRCUIT SCHEMATIC FOR 3N202



(1) Amplitude at Input from Local Oscillator ≈ 3 V RMS

C1 1.5-7.0 pF, ERIE Variable Ceramic, Set for ≈ 4.7 pF
L1 4 Turns, #14 AWG Copper, 1/4" I.D., 1/6" Pitch

FIGURE 3 – 45-MHz TEST CIRCUIT SCHEMATIC
3N203



L1 14 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core
L2 10 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core

6

TYPICAL CHARACTERISTICS

FIGURE 4 – DRAIN CURRENT versus DRAIN to SOURCE VOLTAGE

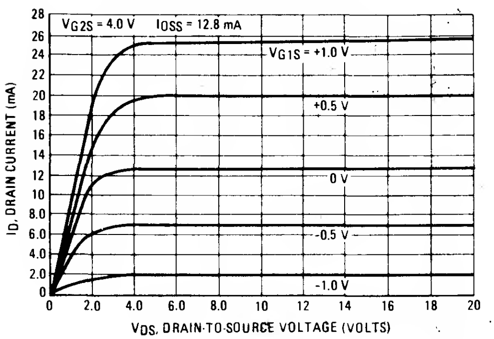


FIGURE 5 – DRAIN CURRENT versus GATE-ONE to SOURCE VOLTAGE

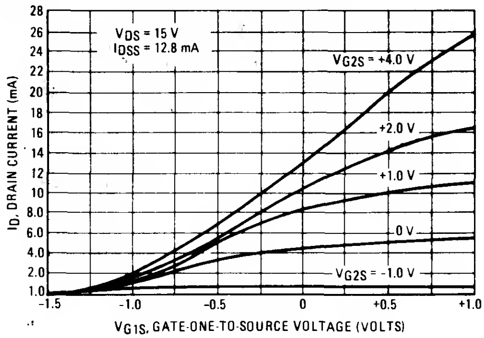


FIGURE 6 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

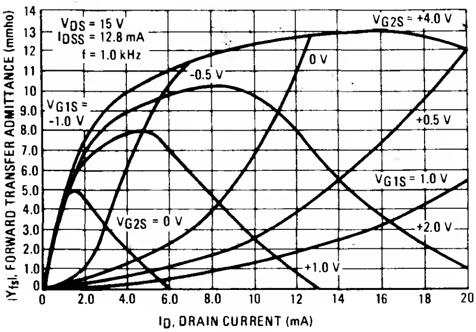


FIGURE 7 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-ONE to SOURCE VOLTAGE

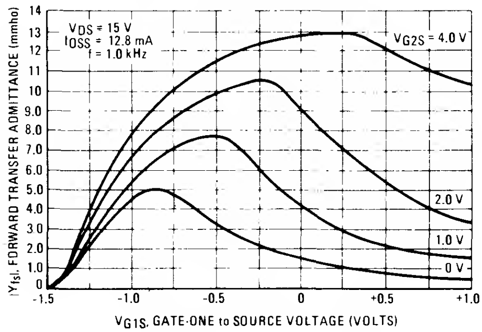


FIGURE 8 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-TWO to SOURCE VOLTAGE

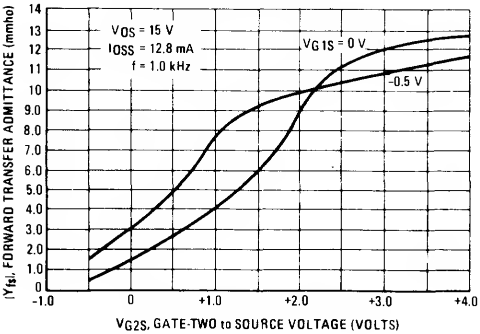
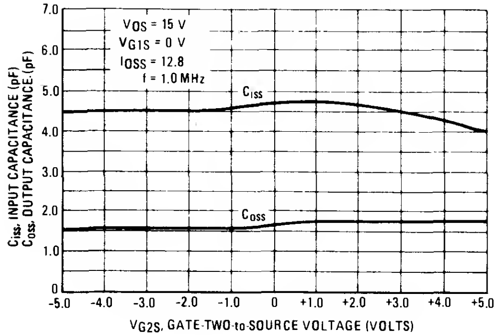


FIGURE 9 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE INPUT AND OUTPUT CAPACITANCE versus GATE-TWO-to-SOURCE VOLTAGE



TYPICAL CHARACTERISTICS

FIGURE 10 – COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus DRAIN CURRENT

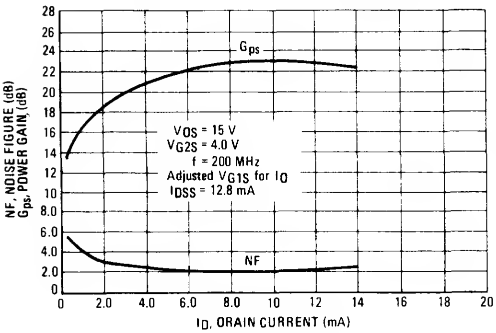


FIGURE 11 – COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus GAIN CONTROL GATE-SUPPLY VOLTAGE – 3N201

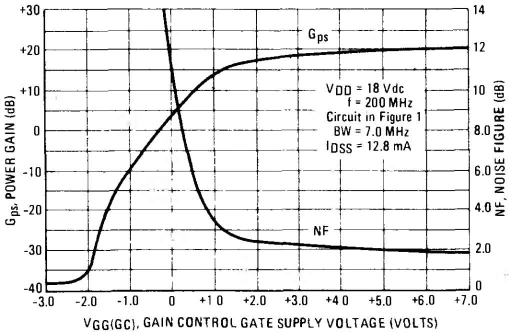


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FIGURE 12 – COMMON-SOURCE POWER GAIN versus DRAIN SUPPLY CURRENT – 3N201

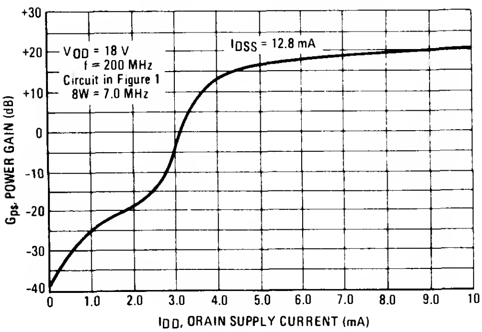


FIGURE 13 – SMALL-SIGNAL COMMON-SOURCE CONVERSION POWER GAIN versus LOCAL OSCILLATOR INPUT VOLTAGE – 3N202

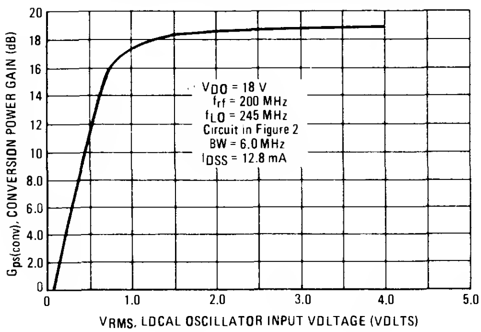
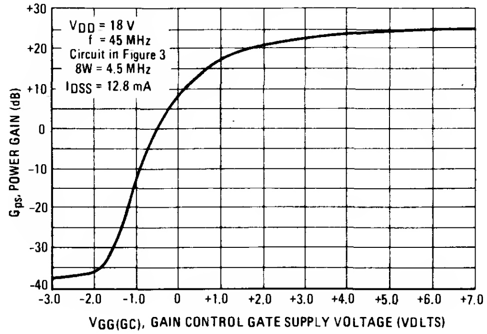


FIGURE 14 – SMALL-SIGNAL COMMON SOURCE INSERTION POWER GAIN versus GAIN CONTROL GATE-SUPPLY VOLTAGE – 3N203



6

TYPICAL CHARACTERISTICS

FIGURE 15 – SMALL-SIGNAL GATE ONE FORWARD TRANSFER ADMITTANCE versus FREQUENCY

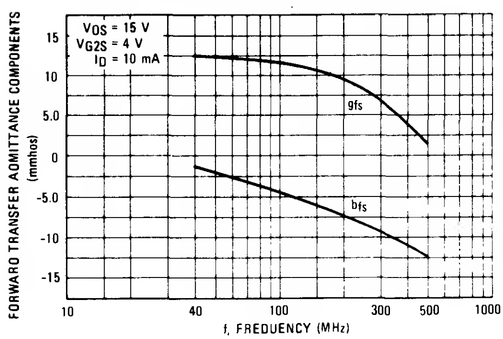


FIGURE 16 – SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

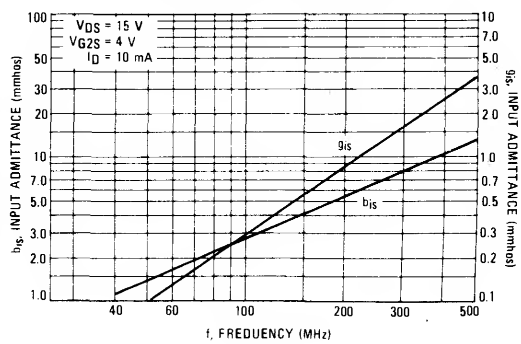
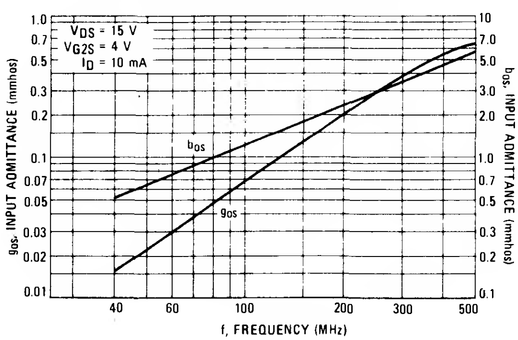


FIGURE 17 – SMALL-SIGNAL GATE ONE OUTPUT ADMITTANCE versus FREQUENCY



3N204
3N205

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL GATE MOS-FET

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Drain Current	I_D	50	mA
Reverse Gate Current	I_G	−10	mA
Forward Gate Current	I_{GF}	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 0.8	mW mW/°C
Lead Temperature	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65°C to +175°C	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (I_D = 10 μA, V_{G1} = V_{G2} = −5.0 V)	$V_{(BR)DSX}$	25	—	Vdc
Gate 1-Source Breakdown Voltage (I_{G1} = ±10 mA) Note 1	$V_{(BR)G1SO}$	±6	±30	Vdc
Gate 2-Source Breakdown Voltage (I_{G2} = ±10 mA) Note 1	$V_{(BR)G2SO}$	±6	±30	Vdc
Gate 1 Leakage Current (V_{G1S} = ±5.0 V, V_{G2S} = V_{DS} = 0)	I_{G1SS}	—	±10	nA
Gate 2 Leakage Current (V_{G2S} = ±5.0 V, V_{G1S} = V_{DS} = 0)	I_{G2SS}	—	±10	nA
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = 20 μA)	$V_{G1S(off)}$	−0.5	−4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 V, V_{G1S} = 0 V, I_D = 20 μA)	$V_{G2S(off)}$	−0.2	−4.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 V, V_{G2S} = 4.0 V, V_{G1S} = 0 V)	I_{DSS}*	6	30	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 V, V_{G2S} = 4.0 V, V_{G1S} = 0 V, f = 1.0 kHz) Note 2	$\|Y_{fs}\|$	10	22	mmhos
Input Capacitance (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = I_{DSS}, f = 1.0 Mhz)	C_{iss}	Typ. 3.0		pF
Reverse Transfer Capacitance (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = 10 mA, f = 1.0 MHz)	C_{rss}	0.005	0.03	pF
Output Capacitance (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = I_{DSS}, f = 1.0 MHz)	C_{oss}	Typ. 1.4		pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DD} = 18 V, V_{GG} = 7.0 V, f = 200 MHz) 3N204 (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = 10 mA, f = 450 MHz) 3N204	NF	 — —	 3.5 5.0	dB
Common Source Power Gain (V_{DD} = 18 V, V_{GG} = 7.0 V, f = 200 MHz) 3N204 (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = 10 mA, f = 450 MHz) 3N204	G_{ps}	 20 14	 28 —	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Bandwidth (V_{DD} = 18 V, V_{GG} = 7.0 V, f = 200 MHz) (V_{DD} = 18 V, f_{LO} = 245 MHz, f_{RF} = 200 MHz) (Note 4)	 3N3204 3N205	BW	 7.0 4.0	 12 7.0	MHz
Gain Control Gate-Supply Voltage (Note 3) (V_{DD} = 18 V, ΔGPS = 300 dB, f = 200 MHz)	 3N204	$V_{GG(GC)}$	0	−2.0	Vdc
Conversion Gain (Note 4) (V_{DD} = 18 V, f_{LO} = 245 MHz, f_{RF} = 200 MHz)	 3N205	$G_{(conv.)}$	17	28	dB

*PW = 30 μsec, Duty Cycle ≤ 2.0%.

(1) All gate breakdown voltages are measured while the device is conducting rated gate current. This insures that the gate voltage limiting network is functioning propertly.

(2) This parameter must be measured with bias voltages applied for less than five (5) seconds to avoid overheating.

(3) ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7.0 V.

(4) Amplitude at input from local oscillator is 3 volts RMS.

6

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Drain-Source Voltage	V_{DS}	25		Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30		Vdc
Drain Current	I_D	30		mAdc
Gate Current	I_{G1R} I_{G1F} I_{G2R} I_{G2F}	−10 10 −10 10		mAdc
		3N209	MPF209	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	— —	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		300 2.4	mW mW/°C
Lead Temperature, 1/16″ From Seated Surface for 10 seconds	T_L	260	200	°C
Storage Channel Temperature Range	T_{stg}	−65 to +175	−65 to +150	°C
Operating Channel Temperature	$T_{channel}$	175	150	°C

3N209
MPF209

3N209
CASE 20-03, STYLE 9
TO-72 (TO-206AF)

MPF209
CASE 317-01, STYLE 1

DUAL-GATE
MOSFET
UHF COMMUNICATIONS

N-CHANNEL — DEPLETION

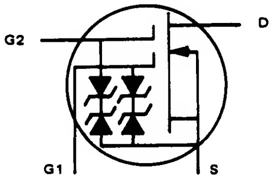
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{G1S} = −4.0 Vdc, V_{G2S} = 4.0 Vdc)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1 — Source Forward Breakdown Voltage (I_{G1} = 10 mAdc, V_{G2S} = V_{DS} = 0)	$V_{(BR)G1SSF}$	7.0	—	22	Vdc
Gate 1 — Source Reverse Breakdown Voltage (I_{G1} = −10 mAdc, V_{G2S} = V_{DS} = 0)	$V_{(BR)G1SSR}$	−7.0	—	−22	Vdc
Gate 2 — Source Forward Breakdown Voltage (I_{G2} = 10 mAdc, V_{G1S} = V_{DS} = 0)	$V_{(BR)G2SSF}$	7.0	—	22	Vdc
Gate 2 — Source Reverse Breakdown Voltage (I_{G2} = −10 mAdc, V_{G1S} = V_{DS} = 0)	$V_{(BR)G2SSR}$	−7.0	—	−22	Vdc
Gate 1 — Terminal Forward Current (V_{G1S} = 6.0 Vdc, V_{G2S} = V_{DS} = 0)	I_{G1SSF}	—	—	20	nAdc
Gate 1 — Terminal Reverse Current (V_{G1S} = −6.0 Vdc, V_{G2S} = V_{DS} = 0) (V_{G1S} = −6.0 Vdc, V_{G2S} = V_{DS} = 0, T_A = 150°C)	I_{G1SSR}	— —	— —	−20 −10	nAdc μAdc
Gate 2 — Terminal Forward Current (V_{G2S} = 6.0 Vdc, V_{G1S} = V_{DS} = 0)	I_{G2SSF}	—	—	20	nAdc
Gate 2 — Terminal Reverse Current (V_{G2S} = −6.0 Vdc, V_{G1S} = V_{DS} = 0) (V_{G2S} = −6.0 Vdc, V_{G1S} = V_{DS} = 0, T_A = 150°C)	I_{G2SSR}	— —	— —	−20 −10	nAdc μAdc
ON CHARACTERISTICS					
Gate 1 — Zero Voltage Drain Current (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)	I_{DSS}	5.0	—	30	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	y_{fs}	10	13	20	mmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D ≥ 5.0 mAdc, f = 1.0 MHz)	C_{iss}	—	3.3	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D ≥ 5.0 mAdc, f = 1.0 MHz)	C_{rss}	0.005	0.023	0.03	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D ≥ 5.0 mAdc, f = 1.0 MHz)	C_{oss}	0.5	2.0	4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 500 MHz)	NF	—	4.0	6.0	dB
Common Source Power Gain (Figure 12) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 500 MHz)	G_{ps}	10	13	20	dB
*Bandwidth (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 500 MHz)	BW	7.0	—	17	MHz

FIGURE 1 — MOS FET CIRCUIT SCHEMATIC



TYPICAL SCATTERING PARAMETERS

FIGURE 2 — S_{11}, INPUT REFLECTION COEFFICIENT versus FREQUENCY

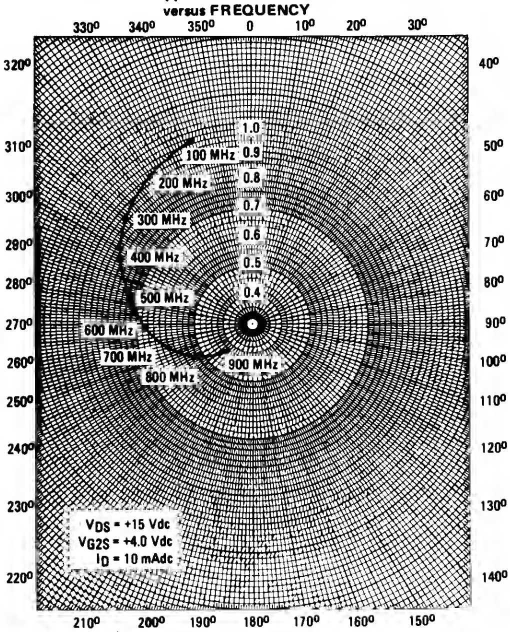


FIGURE 3 — S_{12}, REVERSE TRANSMISSION COEFFICIENT versus FREQUENCY

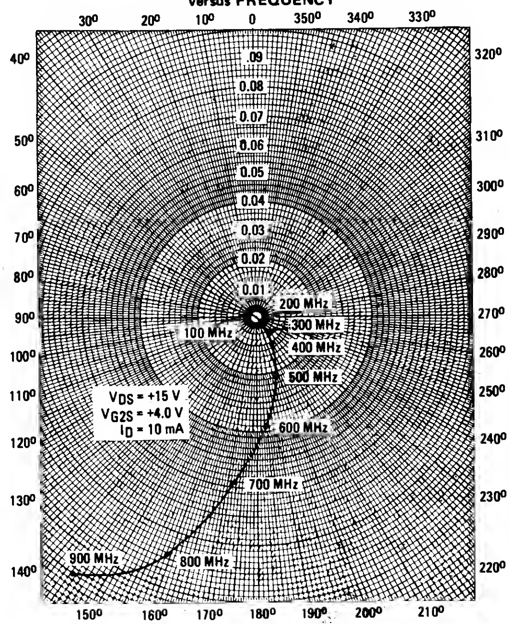


FIGURE 4 – S_{21}, FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY

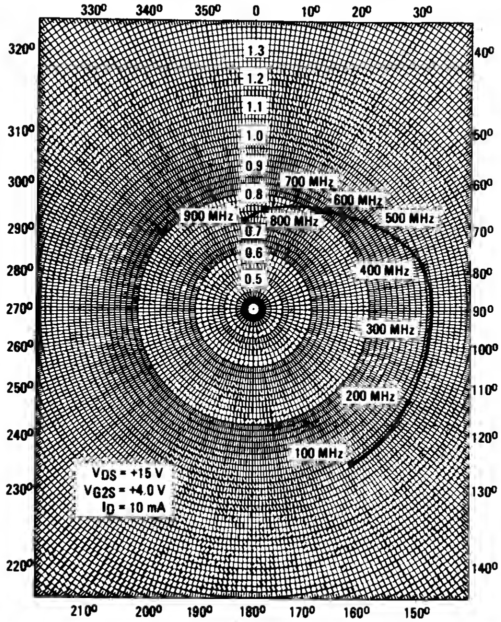
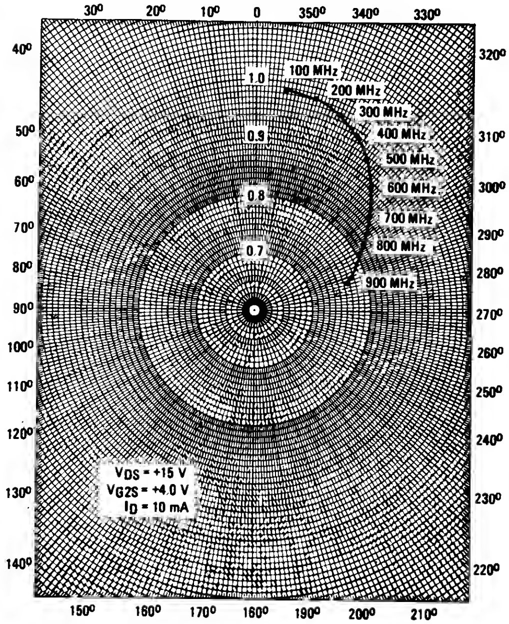


FIGURE 5 – S_{22}, OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



TYPICAL COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{GS2} = 4.0 Vdc, I_D = 10 mAdc)

FIGURE 6 – Y_{11}, INPUT ADMITTANCE versus FREQUENCY

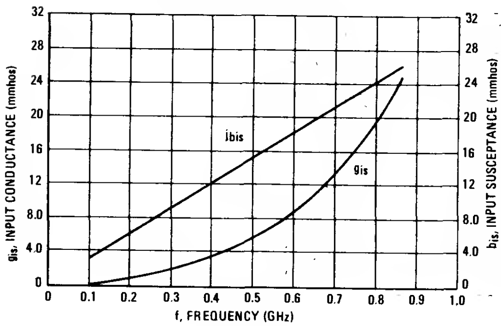
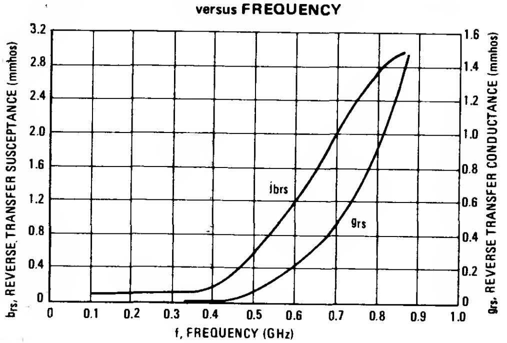


FIGURE 7 – Y_{12}, REVERSE TRANSFER ADMITTANCE versus FREQUENCY



6

FIGURE 8 – Y_{21}, FORWARD TRANSFER ADMITTANCE versus FREQUENCY

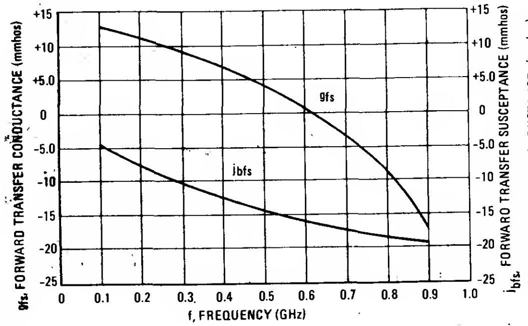


FIGURE 9 – Y_{22}, OUTPUT ADMITTANCE versus FREQUENCY

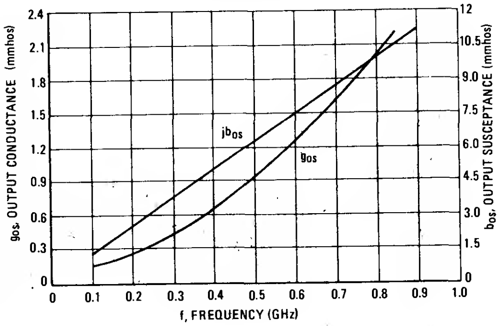
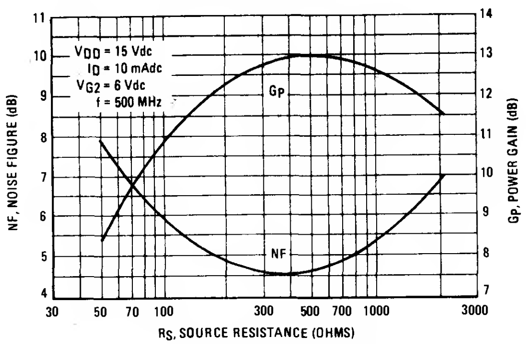


FIGURE 10 – POWER GAIN AND NOISE FIGURE versus SOURCE RESISTANCE
(See Schematic Figure 12)



The Test Circuit shown in Figure 12 was used to generate Power Gain and Noise Figure as a function of Source Resistance curves.

FIGURE 11 – THIRD ORDER INTERMODULATION DISTORTION
(See Schematic Figure 12)

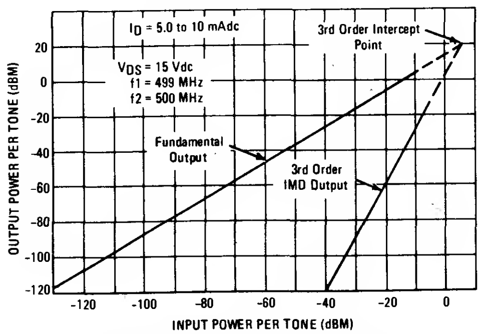
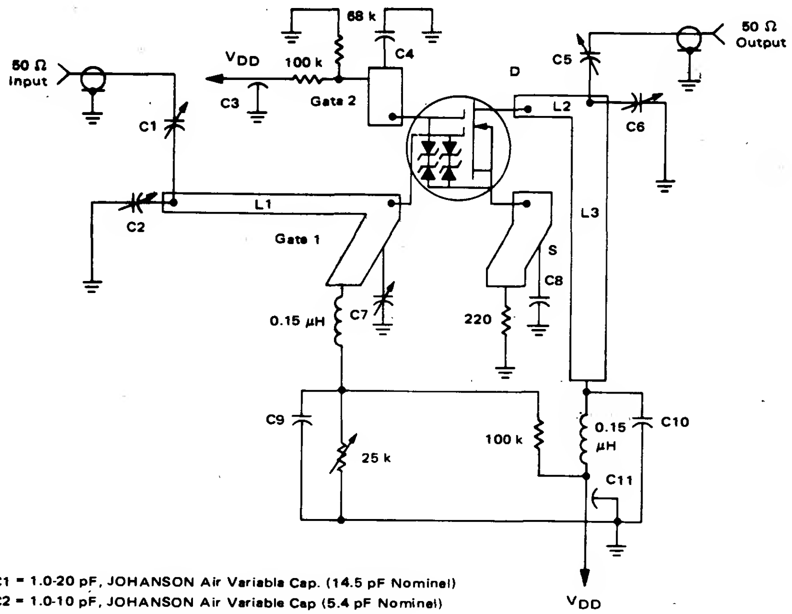


Figure 11 shows the typical third order intermodulation distortion (IMD) performance of the 3N209 and 3N210 at 500 MHz.

Both fundamental output and third order IMD output characteristics are plotted. The curves have been extrapolated to show the third order intermodulation output intercept point.

The performance is typical for I_D between 5.0 mAdc and 10 mAdc. The test circuit shown in Figure 12 was used to generate the IMD Data.

FIGURE 12 – TEST CIRCUIT FOR POWER GAIN, NOISE FIGURE AND THIRD ORDER INTERMODULATION DISTORTION



C1 = 1.0-20 pF, JOHANSON Air Variable Cap. (14.5 pF Nominal)
C2 = 1.0-10 pF, JOHANSON Air Variable Cap (5.4 pF Nominal)
C3, C11 = 470 pF, Low Inductance Feedthru Cap.
C4, C8, C9, C10 = 250 pF, Low Inductance, UNDERWOOD Cap. (J-101)
C5 = 0.4-6.0 pF, JOHANSON Air Variable Cap. (0.92 pF Nominal)
C6 = 1.0-10 pF, JOHANSON Air Variable Cap. (5.9 pF Nominal)
C7 = 1.0-10 pF, JOHANSON Air Variable Cap (3.0 pF Nominal)
L1 = 2.52 x 0.1 inches
L2 = 0.4 x 0.1 inches
L3 = 1.23 x 0.2 inches
} On 2 sided glass Teflon®, 1 oz. copper clad, 1/16" $\epsilon_R = 2.55$

®Trademark of E.I. Dupont, DeNemours and Co., Inc.

6

3N211
3N212
3N213

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE
MOSFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	3N211 3N212	3N213	Unit
Drain-Source Voltage	V_{DS}	27	35	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	35 35	40 40	Vdc
Drain Current	I_D	50		mAdc
Gate Current	I_{G1} I_{G2}	±10 ±10		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 8.0		Watt mW/°C
Lead Temperature, 1/16" From Seated Surface for 10 seconds	T_L	300		°C
Junction Temperature Range	T_J	−65 to +175		°C
Storage Temperature Range	T_{stg}	−65 to +175		°C

Refer to MPF211 for graphs.

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{G1S} = V_{G2S} = −4.0 Vdc)	3N211,212 3N213	$V_{(BR)DSX}$	25 30	— —	Vdc
Instantaneous Drain-Source Breakdown Voltage(1) (I_D = 10 μAdc, V_{G1S} = V_{G2S} = −4.0 Vdc)	3N211,212 3N213	$V_{(BR)DSX}$	27 35	— —	Vdc
Gate 1-Source Breakdown Voltage(2) (I_{G1} = ±10 mAdc, V_{G2S} = V_{DS} = 0)		$V_{(BR)G1SO}$	±6.0	—	Vdc
Gate 2-Source Breakdown Voltage(2) (I_{G2} = ±10 mAdc, V_{G1S} = V_{DS} = 0)		$V_{(BR)G2SO}$	±6.0	—	Vdc
Gate 1 Leakage Current (V_{G1S} = ±5.0 Vdc, V_{G2S} = V_{DS} = 0) (V_{G1S} = −5.0 Vdc, V_{G2S} = V_{DS} = 0, T_A = 150°C)		I_{G1SS}	— —	±10 −10	nAdc μAdc
Gate 2 Leakage Current (V_{G2S} = ±5.0 Vdc, V_{G1S} = V_{DS} = 0) (V_{G2S} = −5.0 Vdc, V_{G1S} = V_{DS} = 0, T_A = 150°C)		I_{G2SS}	— —	±10 −10	nAdc μAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 20 μAdc)	3N211,213 3N212	$V_{G1S(off)}$	−0.5 −0.5	−5.5 −4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 20 μAdc)	3N211 3N212,213	$V_{G2S(off)}$	−0.2 −0.2	−2.5 −4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(3) (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)		I_{DSS}	6.0	40	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(4) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, V_{G1S} = 0, f = 1.0 kHz)	3N211,212 3N213	$\|y_{fs}\|$	17 15	40 35	mmhos
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{rss}	0.005	0.05	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz)	3N211 3N211,13	NF	— —	3.5 4.0	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Common Source Power Gain		G_{ps}			dB
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz)	3N211		24	35	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz)	3N211		29	37	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz)	3N213		27	35	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz)	3N212	G_c(6)	21	28	
Bandwidth		BW			MHz
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz)	3N211		5.0	12	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz)	3N212		4.0	7.0	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz)	3N211,213		3.5	6.0	
Gain Control Gate-Supply Voltage(5)		$V_{GG(GC)}$			Vdc
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 200 MHz)	3N211		—	−2.0	
(V_{DD} = 24 Vdc, ΔG_{ps} = −30 dB, f = 45 MHz)	2N211,213		—	±1.0	

(1) Measured after five seconds of applied voltage.
(2) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage limiting network is functioning properly.
(3) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
(4) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating. The signal is applied to gate 1 with gate 2 at ac ground.
(5) ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7.0 Volts (3N211) and V_{GG} = 6.0 Volts (3N213).
(6) Power Gain Conversion. Amplitude at input from local oscillator is adjusted for maximum G_c.

BC264,A,B,C,D

CASE 29-02, STYLE 23
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	100	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.88	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	—	Vdc
Gate-Source (V_{DS} = 15 Vdc) BC264(1) I_D = 200 μA	V_{GS}	0.4			Vdc
BC264A I_D = 1 mA		0.2	—	1.2	
BC264B I_D = 1.5 mA		0.4	—	1.4	
BC264C I_D = 2.5 mA		0.5	—	1.5	
BC264D I_D = 3.5 mA		0.6	—	1.6	
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nA)	$V_{GS(off)}$	0.5	—	8	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	10	nAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current V_{DS} = 15 V BC264	I_{DSS}	2.0		12.0	mAdc
BC264A		2.0		4.5	
BC264B		3.5		6.5	
BC264C		5.0		8.0	
BC264D		7.0		12.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 KHz) BC264	(Y_{fs})	2.5			mmhos
BC264A		2.5			
BC264B		3.0			
BC264C		3.5			
BC264D		4.0			
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 KHz)	(Y_{OS})		40		μmhos
Reverse Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$\|Y_{rs}\|$		1.0		mmhos
Input Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1 Vdc)	C_{iss}		3		pF
Reverse Transfer Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1 Vdc, f = 1 MHz)	C_{rss}		0.7		pF
Output Capacitance (V_{DS} = 20 Vds, $-V_{GS}$ = 1 Vdc, f = 1 MHz)	C_{oss}		0.9		pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1 kΩ, f = 100 MHz)	N_F		1.5		db
Cut-off Frequency (2) (V_{DS} = 15 Vdc, V_{GS} = 0)	f_{gfs}		700		MHz

(1) On orders against the BC264 any or all subgroups might be shipped.
(2) The frequency at which gfs is 0.7 of its value at 1 kHz.

BF244,A,B,C

CASE 29-02, STYLE 22
TO-92 (TO-226AA)

BF245,A,B,C

CASE 29-02, STYLE 23
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	100	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.88	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	V
Gate-Source (V_{DS} = 15 Vdc, I_D = 200 μA)	BF245(1), BF244(2) BF245A, BF244A BF245B, BF244B BF245C, BF244C	V_{GS}	0.4 0.4 1.6 3.2	— — — —	7.5 2.2 3.8 7.5	V
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nA)		$V_{GS(off)}$	0.5	—	8	V
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	5	nA
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	BF245(1), BF244(2) BF245A, BF244A BF245B, BF244B BF245C, BF244C	I_{DSS}	2 2 6 12		25 6.5 15 25	mA
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 KHz)		$\|Y_{fs}\|$	3.0		6.5	mmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 KHz)		$\|Y_{os}\|$		40		μmhos
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$\|Y_{fs}\|$		5.6		mmhos
Reverse Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$\|Y_{rs}\|$		1.0		mmhos
Input Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1 Vdc)		C_{iss}		3		pF
Reverse Transfer Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1 Vdc, f = 1 MHz)		C_{rss}		0.7		pF
Output Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1 Vdc, f = 1 MHz)		C_{oss}		0.9		pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1 KΩ, f = 100 MHz)		N_F		1.5		db
Cut-off Frequency(3) (V_{DS} = 15 Vdc, V_{GS} = 0)		$F_{(Yfs)}$		700		MHz

(1) On orders against the BF245, any or all subgroups might be shipped.
(2) On orders against the BF244, any or all subgroups might be shipped.
(3) The frequency at which gfs is 0.7 of its value at 1 KHz.

BF246,A,B,C

CASE 29-02, STYLE 22
TO-92 (TO-226AA)

BF247,A,B,C

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

Refer to MPF4391 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Drain Current	I_D	100	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.88	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1 μA, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	—	V
Gate-Source (V_{DS} = 15 V, I_D = 200 μA)	BF246, BF247 BF246A, BF247A BF246B, BF247B BF246C, BF247C	V_{GS}	0.5 1.5 3 5.5	— — — —	14 4 7 12	V
Gate-Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)		$V_{GS(off)}$	0.6	—	14.5	V
Gate Cutoff Current (V_{GS} = 15 V, V_{DS} = 0)		I_{GSS}	—	—	5	nA
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	BF246, BF247 BF246A, BF247A BF246B, BF247B BF246C, BF247C	I_{DSS}	30 30 60 110		250 80 140 250	mA
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 V, I_D = 10 mA, f = 1 kHz)		$\|Y_{fs}\|$	8	23		mmhos
Reverse Transfer Capacitance (V_{DS} = 15 V, I_D = 10 mA, f = 1 kHz)		C_{rss}		3.3		pF
Input Capacitance (V_{DS} = 15 V, I_D = 10 mA, f = 1 MHz)		C_{in}		6		pF
Output Capacitance (V_{DS} = 15 V, I_D = 10 mA, f = 1 MHz)		C_{out}		5		pF
Cutoff Frequency (V_{DS} = 15 V, V_{GS} = 0)		$F_{(Yfs)}$		450		MHz

BF256,A,B,C

CASE 29-02, STYLE 23
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	100	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.88	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 200 μA)		$V_{GS(off)}$	0.5	—	7.5	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	5	nAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current) (V_{DS} = 15 Vdc, V_{GS} = 0)	BF256(1) BF256A BF256B BF256C	I_{DSS}	3 3 6 11	— — — —	18 7 13 18	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)		$\|Y_{fs}\|$	4.5	5	—	mmhos
Reverse Transfer Capacitance (V_{DS} = 20 Vdc, $-V_{GS}$ = 1Vdc, f = 1 MHz)		C_{rss}	—	0.7	—	pF
Output Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1 MHz)		C_{oss}	—	1.0	—	pF
Noise Figure (V_{DS} = 10 Vdc, R_s = 47Ω, f = 800 MHz)		N_F	—	7.5	—	db
Cut-off Frequency(2) (V_{DS} = 15 Vdc, V_{GS} = 0)		f_{gfs}	—	1000	—	MHz
Power Gain (V_{DS} = 15 Vdc, R_s = 47 Ω, f =800 MHz)		G_p	—	11	—	dB

(1) On orders against the BF256, any or all subgroups might be shipped.
(2) The frequency at which gfs is 0.7 of its value at 1 kHz.

BFW10

BFW11

CASE 20-03, STYLE 1
TO-72 (TO-206A)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

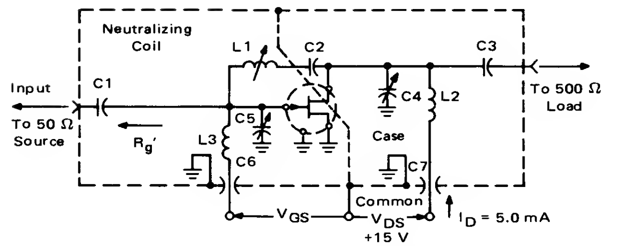
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	BFW10 BFW11	$V_{GS(off)}$	—	—	8 6	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	0.1	nAdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 400 μAdc)	BFW10	V_{GS}	2	—	7.5	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 50 μAdc)	BFW11	V_{GS}	1.25	—	4	Vdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	BFW10 BFW11	I_{DSS}	8 4	— —	20 10	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	BFW10 BFW11	Y_{fs}	3.5 3.0	— —	6.5 6.5	mmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	BFW10 BFW11	Y_{os}	— —	— —	85 50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)		C_{rss}	—	—	0.8	pF
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		Y_{fs}	3.2	—	—	mmhos
Equivalent Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 25 Hz)		e_n	—	—	75	nV/$\sqrt{Hz}$
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0 V, see Figures 1, 2, 3)		NF	—	—	2.5	dB

FIGURE 1 – 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1-12 pF	0.8-8.0 pF
C5	1-12 pF	0.8-8.0 pF
C6	0.0015 µF	0.001 µF
C7	0.0015 µF	0.001 µF
L1	3.0 µH*	0.2 µH**
L2	0.15 µH*	0.03 µH**
L3	0.14 µH*	0.022 µH**

Adjust V_{GS} for I_D = 50 mA, V_{GS} < 0 Volts

NOTE: The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

*L1 17 turns, (approx. – depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).

L3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

**L1 6 turns, (approx. – depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).

L3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).

NOISE FIGURE

($T_{channel}$ = 25°C)

FIGURE 2 – EFFECTS OF DRAIN-SOURCE VOLTAGE

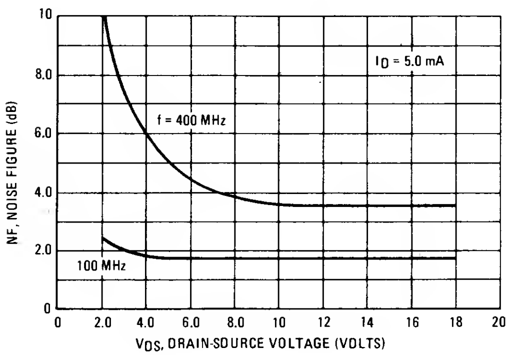
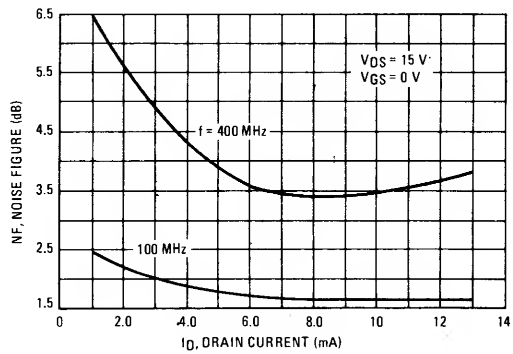


FIGURE 3 – EFFECTS OF DRAIN CURRENT



6

BS107,A

CASE 29-02, STYLE 30
TO-92 (TO-226AA)

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to MFE9200 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	200	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current Continuous(1) Pulsed(2)	 I_D I_{DM}	 250 500	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.6	Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to 150	°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 130$ V, $V_{GS} = 0$)	I_{DSS}	—	—	30	nAdc
Drain-Source Breakdown Voltage ($V_{GS} = 0$, $I_D = 10$ μA)	$V_{(BR)DSX}$	200	—	—	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	0.01	10	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage ($I_D = 1.0$ mA, $V_{DS} = V_{GS}$)	$V_{GS(Th)}$	1.0	—	3.0	Vdc
Static Drain-Source On Resistance	$r_{DS(on)}$				Ohms
BS107					
($V_{GS} = 2.6$ V, $I_D = 20$ mA)					
($V_{GS} = 10$ V, $I_D = 200$ mA)		—	—	28	
BS107A		—	—	14	
($V_{GS} = 10$ Vdc)					
($I_D = 100$ mA)		—	4.5	6.0	
($I_D = 250$ mA)		—	4.8	6.4	
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance ($V_{DS} = 25$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	72	90	pF
Reverse Transfer Capacitance ($V_{DS} = 25$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	2.8	3.5	pF
Output Capacitance ($V_{DS} = 25$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{oss}	—	15	20	pF
Forward Transconductance ($V_{DS} = 25$ V, $I_D = 250$ mA)	g_{fs}	200	400	—	mmhos
SWITCHING CHARACTERISTICS					
Turn-On Time	t_{on}	—	6.0	15	ns
Turn-Off Time	t_{off}	—	12	15	ns

***Pulse Test:** Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

6

BS170

CASE 29-02, STYLE 30
TO-92 (TO-226AA)

TMOS FET
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current(1)	I_D	0.5	Adc
Total Device Dissipation @ $T_C = 25°C$	P_D	0.83	Watt
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate Reverse Current ($V_{GS} = 15$ V, $V_{DS} = 0$)	I_{GSS}	—	0.01	10	nAdc
Drain-Source Breakdown Voltage ($V_{GS} = 0$, $I_D = 100\ \mu A$)	$V_{(BR)DSS}$	60	90	—	Vdc
ON CHARACTERISTICS(2)					
Gate Threshold Voltage ($V_{DS} = V_{GS}$, $I_D = 1.0$ mA)	$V_{GS(Th)}$	0.8	2.0	3.0	Vdc
Static Drain-Source On Resistance ($V_{GS} = 10$ V, $I_D = 200$ mA)	$r_{DS(on)}$	—	1.8	5.0	Ohms
Drain Cutoff Current ($V_{DS} = 25$ V, $V_{GS} = 0$ V)	$I_{D(off)}$	—	—	0.5	μA
Forward Transconductance ($V_{DS} = 10$ V, $I_D = 250$ mA)	g_{fs}	—	200	—	mmhos
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance ($V_{DS} = 10$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	60	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_D = 0.2$ A) See Figure 1	t_{on}	—	4.0	10	ns
Turn-Off Time ($I_D = 0.2$ A) See Figure 1	t_{off}	—	4.0	10	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

6

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

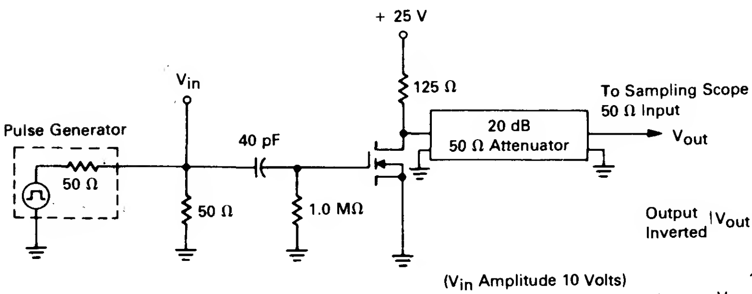


FIGURE 2 — SWITCHING WAVEFORMS

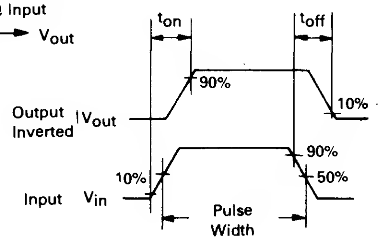


FIGURE 3 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

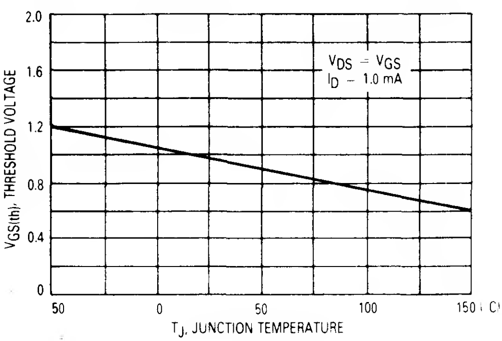


FIGURE 4 — ON-REGION CHARACTERISTICS

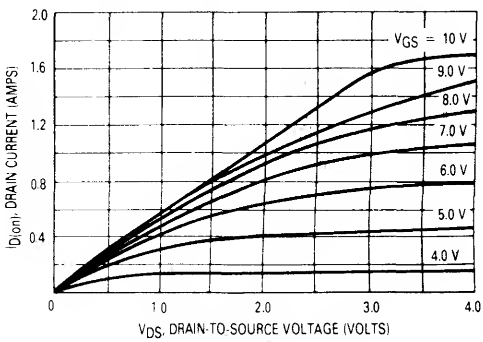


FIGURE 5 — OUTPUT CHARACTERISTICS

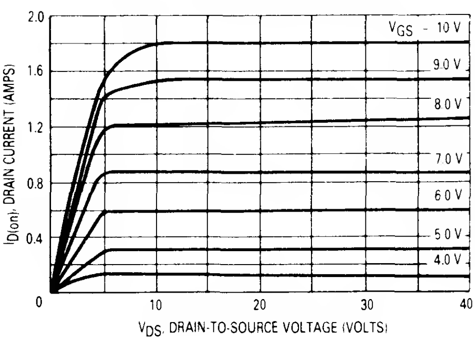
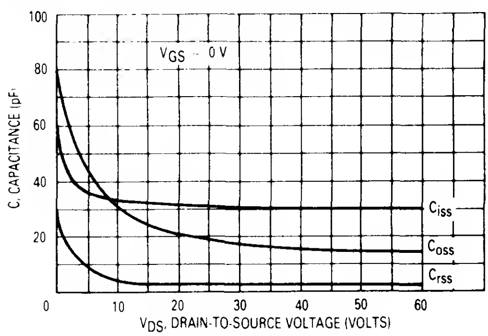


FIGURE 6 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE



J107, J108
J109, J110

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
GENERAL-PURPOSE
TRANSISTOR

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	135	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (V_{DS} = 0, I_G = −10 μAdc)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 −3.0 −200	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 J107 J108 J109 J110	$V_{GS(off)}$	 −0.5 −3.0 −2.0 −0.5	 — — — —	 −4.5 −10 −6.0 −4.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15, V_{GS} = 0)	 J107 J108 J109 J110	I_{DSS}	 100 80 40 10	 — — — —	 — — — —	mAdc
Drain-Source On-Resistance (V_{DS} < 0.1 V, V_{GS} = 0 V)	 J107 J108 J109 J110	$r_{DS(on)}$	 — — — —	 — — — —	 8.0 8.0 12 18	ohms
SMALL-SIGNAL CHARACTERISTICS						
Drain Gate + Source Gate On-Capacitance (V_{DS} = 0 Vdc, V_{GS} = 0, f = 1.0 MHz)		$C_{dg(on)}$ + $C_{sg(on)}$	—	—	85	pF
Drain Gate Off-Capacitance (V_{DS} = 0 Vdc, V_{GS} = −10 V, f = 1.0 MHz)		$C_{dg(off)}$	—	—	15	pF
Source Gate Off-Capacitance (V_{DS} = 0 Vdc, V_{GS} = −10 V, f = 1.0 MHz)		$C_{sg(off)}$	—	—	15	pF

(1) Pulse Duration 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — COMMON SOURCE INPUT CAPACITANCE versus GATE-SOURCE VOLTAGE

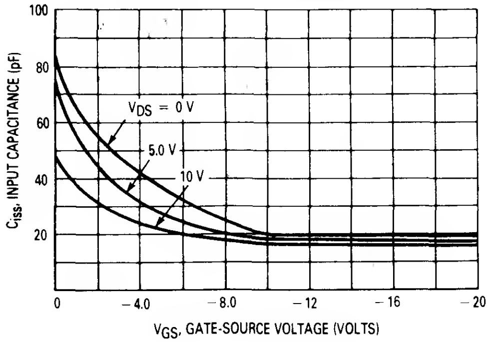


FIGURE 2 — COMMON SOURCE REVERSE FEEDBACK CAPACITANCE versus GATE-SOURCE VOLTAGE

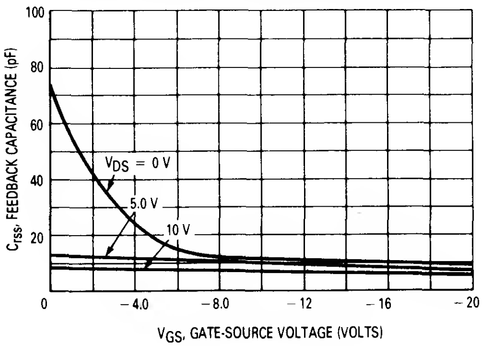


FIGURE 3 — ON-RESISTANCE versus GATE-SOURCE CUTOFF VOLTAGE

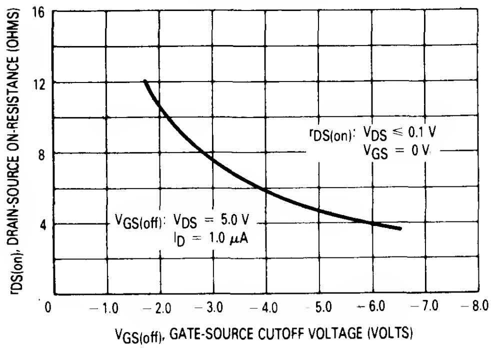


FIGURE 4 — OUTPUT CHARACTERISTIC

$V_{GS(off)} = -2.0$ V

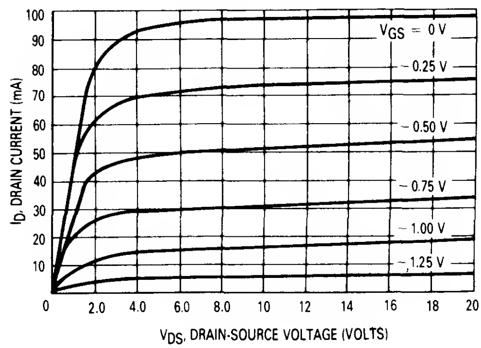


FIGURE 5 — OUTPUT CHARACTERISTIC

$V_{GS(off)} = -3.0$ V

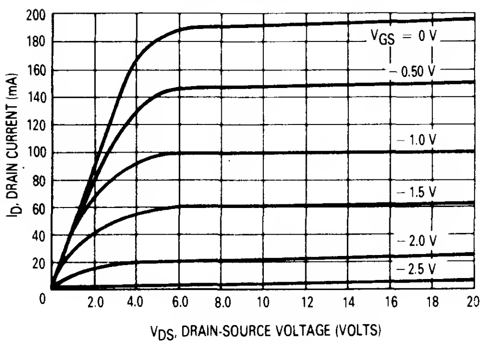


FIGURE 6 — OUTPUT CHARACTERISTIC

$V_{GS(off)} = -4.0$ V

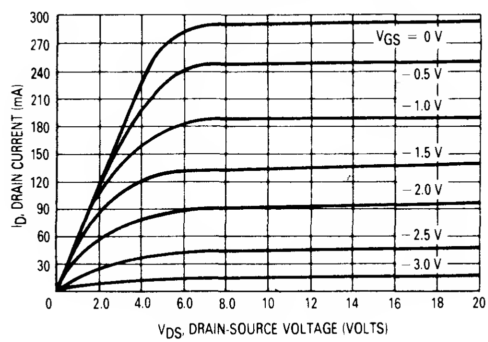
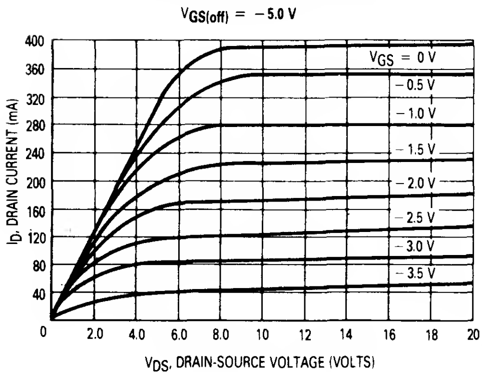


FIGURE 7 — OUTPUT CHARACTERISTIC



6

J111
J112
J113

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
CHOPPER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−35	Vdc
Gate-Source Voltage	V_{GS}	−35	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.68	mW mW/°C
Lead Temperature	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μA)		$V_{(BR)GSS}$	35	—	Vdc
Gate Reverse Current (V_{GS} = −15 V)		I_{GSS}	—	−1.0	nA
Gate Source Cutoff Voltage (V_{DS} = 5.0 V, I_D = 1.0 μA)	J111 J112 J113	$V_{GS(off)}$	−3.0 −1.0 −0.5	−10 −5.0 −3.0	V
Drain-Cutoff Current (V_{DS} = 5.0 V, V_{GS} = −10 V)		$I_{D(off)}$	—	1.0	nA
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 V)	J111 J112 J113	I_{DSS}	20 5.0 2.0	— — —	mA
Static Drain-Source On Resistance (V_{DS} = 0.1 V)	J111 J112 J113	$r_{DS(on)}$	— — —	33 50 100	Ohms
Drain Gate and Source Gate On-Capacitance (V_{DS} = V_{GS} = 0, f = 1.0 MHz)		$C_{dg(on)}$ + $C_{sg(on)}$	—	28	pF
Drain Gate Off-Capacitance (V_{GS} = −10 V, f = 1.0 MHz)		$C_{dg(off)}$	—	5.0	pF
Source Gate Off-Capacitance (V_{GS} = −10 V, f = 1.0 MHz)		$C_{sg(off)}$	—	5.0	pF

*Pulse Width = 300 μsec, Duty Cycle = 3.0%.

J174
J175
J176
J177

CASE 29-02, STYLE 7
TO-92 (TO-226AA)

JFET
CHOPPER TRANSISTOR

P-CHANNEL — DEPLETION

Refer to MPF970 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Volts)		I_{GSS}	—	1.0	nA
Gate Source Cutoff Voltage (V_{DS} = −15 V, I_D = −10 nA)	J174 J175 J176 J177	$V_{GS(off)}$	5.0 3.0 1.0 0.8	10 6.0 4.0 2.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = −15 V)	J174 J175 J176 J177	I_{DSS}*	−2.0 −7.0 −2.0 −1.5	−100 −60 −25 −20	mA
Static Drain-Source On Resistance (V_{DS} ≤ −0.1 Volt)	J174 J175 J176 J177	$r_{DS(on)}$	— — — —	85 125 250 300	Ω

*Pulse Width = 300 μs, Duty Cycle ≤ 3.0%.

J201
J202
J203

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
LOW FREQUENCY/LOW NOISE

N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μA)		$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current (V_{GS} = −20 V)		I_{GSS}	—	−100	pA
Gate Source Cutoff Voltage (V_{DS} = 20 V, I_D = 10 nA)	J201 J202 J203	$V_{GS(off)}$	−0.3 −0.8 −2.0	−1.5 −4.0 −10.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 20 V)	J201 J202 J203	I_{DSS}*	0.2 0.9 4.0	1.0 4.5 20.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 20 V, f = 1.0 kHz)	J201 J202 J203	$\|y_{fs}\|$*	500 1000 1500	— — —	μmhos

*Pulse Width ≤ 2.0 msec.

J270
J271

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
CHOPPER TRANSISTOR

P-CHANNEL — DEPLETION

Refer to MPF970 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	360 3.27	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Volts)		I_{GSS}	—	200	pA
Gate Source Cutoff Voltage (V_{DS} = −15 V, I_D = −1.0 nA)	J270 J271	$V_{GS(off)}$	0.5 1.5	2.0 4.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = −15 V)	J270 J271	I_{DSS}*	−2.0 −6.0	−15 −50	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = −15 V, f = 1.0 kHz)	J270 J271	$\|y_{fs}\|$	6000 8000	15000 18000	μmhos
Output Admittance (V_{DS} = −15 V, f = 1.0 kHz)	J270 J271	$\|y_{os}\|$	— —	200 500	μmhos
Input Capacitance (V_{DS} = −15 V, f = 1.0 MHz)		C_{iss}	—	32	pF
Reverse Transfer Capacitance (V_{DS} = −15 V, f = 1.0 MHz)		C_{rss}	—	8.0	pF

*Pulse Width ≤ 2.0 ms.

6

J300

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−25	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 3.5	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	300	°C
Junction Temperature Range	T_J	−55 to +150	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current (V_{GS} = −15 V, V_{DS} = 0)	I_{GSS}	—	500	pA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 mA)	$V_{GS(off)}$	−1.0	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	I_{DSS}	6.0	30	mA
Gate-Source Forward Voltage (V_{DS} = 0, I_G = 1.0 mA)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 kHz)	$\|y_{fs}\|$	4500	9000	μmhos
Output Admittance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 kHz)	$\|y_{os}\|$	—	200	μmhos
Input Capacitance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 MHz)	C_{iss}	—	5.5	pF
Reverse Transfer Capacitance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 MHz)	C_{rss}	—	1.7	pF

J304
J305

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY
AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−30	Vdc
Gate-Source Voltage	V_{GS}	−30	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 3.5	mW mW/°C
Lead Temperature (1/16" from Case for 10 Seconds)	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = −20 V, V_{DS} = 0)		I_{GSS}	—	100	pA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 1.0 nA)	J304 J305	$V_{GS(off)}$	−2.0 −0.5	−6.0 −3.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	J304 J305	I_{DSS}	5.0 1.0	15 8.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Output Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	50	μmhos
Forward Transconductance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	J304 J305	$Re(y_{fs})$	4500 3000	7500 —	μmhos

J308
J309
J310

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to U308 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 3.5	mW mW/°C
Junction Temperature Range	T_J	−55 to +125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −1.0 μA, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 V, V_{DS} = 0, T_A = 25°C) (V_{GS} = −15 V, V_{DS} = 0, T_A = +125°C)		I_{GSS}	 — —	 — —	 −1.0 −1.0	 nA μA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 nA)	 J308 J309 J310	$V_{GS(off)}$	 −1.0 −1.0 −2.0	 — — —	 −6.5 −4.0 −6.5	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 10 V, V_{GS} = 0)	 J308 J309 J310	I_{DSS}	 12 12 24	 — — —	 60 30 60	mA
Gate-Source Forward Voltage (V_{DS} = 0, I_G = 1.0 mA)		$V_{GS(f)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Common-Source Input Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)	 J308 J309 J310	$Re(y_{is})$	 — — —	 0.7 0.7 0.5	 — — —	mmhos
Common-Source Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		$Re(y_{os})$	—	0.25	—	mmhos
Common-Gate Power Gain (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		G_{pg}	—	16	—	dB
Common-Source Forward Transconductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		$Re(y_{fs})$	—	12	—	mmhos
Common-Gate Input Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		$Re(y_{ig})$	—	12	—	mmhos
Common-Gate Forward Transconductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	 J308 J309 J310	g_{fs}	 8000 10000 8000	 — — —	 20000 20000 18000	μmhos
Common-Gate Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	 J308 J309 J310	g_{os}	 — — —	 — — —	 200 150 200	μmhos

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common-Gate Forward Transconductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	J308	g_{fg}	—	13000	—	μmhos
	J309		—	13000	—	
	J310		—	12000	—	
Common-Gate Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	J308	g_{og}	—	150	—	μmhos
	J309		—	100	—	
	J310		—	150	—	
Gate-Drain Capacitance (V_{DS} = 0, V_{GS} = −10 V, f = 1.0 MHz)		C_{gd}	—	1.8	2.5	pF
Gate-Source Capacitance (V_{DS} = 0, V_{GS} = −10 V, f = 1.0 MHz)		C_{gs}	—	4.3	5.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 10 V, I_D = 10 mA, f = 450 MHz)		NF	—	1.5	—	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 10 V, I_D = 10 mA, f = 100 Hz)		$\bar{e}_n$	—	10	—	$nV/\sqrt{Hz}$

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

6

JF1033B
JF1033S
JF1033Y

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY AMPLIFIER

N-CHANNEL DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Drain Current	I_D	20	mA
Forward Gate Current	I_{GF}	10	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -10\ \mu A$)	$V_{(BR)GSS}$	−25	—	Vdc
Drain-Source Breakdown Voltage ($I_D = 10\ \mu A$)	$V_{(BR)DGO}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = -10$ V, $V_{DS} = 0$)	I_{GSS}	—	−100	nA
Gate Source Cutoff Voltage ($V_{DS} = 10$ V, $I_D = 10\ \mu A$)	$V_{GS(off)}$	−1.0	−8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 10$ V, $V_{GS} = 0$) JF1033Y JF1033B JF1033S	I_{DSS}	2.5 5.0 10.0	6.0 12.0 20.0	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transconductance ($V_{DS} = 10$ V, $V_{GS} = 0$, f = 1.0 kHz)	$Re(y_{fs})$	4.5	13.0	mmhos
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 10$ V, $V_{GS} = 0$, f = 100 MHz)	NF	—	2.5	dB

MFE120
MFE121
MFE122

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE MOSFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+25	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

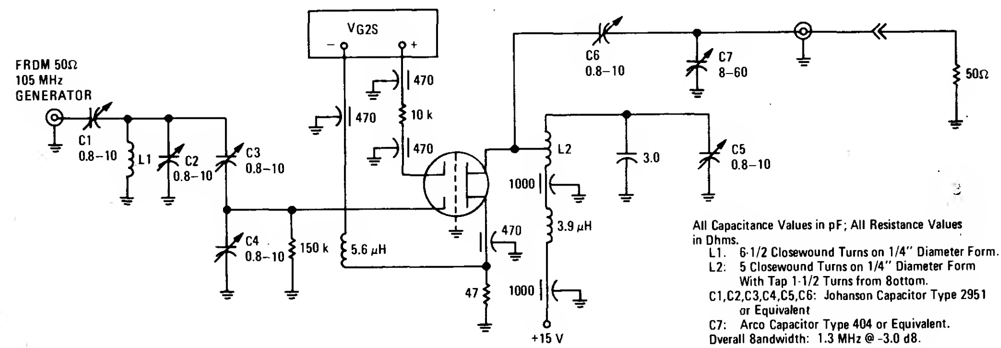
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = 100 μAdc, V_S = 0, V_{G1S} = −4.0 V, V_{G2S} = + 4.0 V)		$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage (I_{G1} = ±10 μAdc, V_{G2S} = 0)		$V_{(BR)G1SO}$	±7.0	—	±20	Vdc
Gate 2-Source Breakdown Voltage (I_{G2} = ±10 μAdc, V_{G2S} = 0)		$V_{(BR)G2SO}$	±7.0	—	±20	Vdc
Gate 1 Leakage Current (V_{G1S} = +6.0 Vdc, V_{G2S} = 0, V_{DS} = 0)		I_{G1SS}	—	—	20	nAdc
Gate 2 Leakage Current (V_{G2S} = +6.0 Vdc, V_{G1S} = 0, V_{DS} = 0)		I_{G2SS}	—	—	20	nAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 200 μAdc)		$V_{G1S(off)}$	—	—	−4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 200 μAdc)		$V_{G2S(off)}$	—	—	−4.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)	MFE120 MFE121 MFE122	I_{DSS}	2.0 5.0 2.0	7.0 10 9.0	18 30 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (Gate 1 to Drain) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	MFE120,22 MFE121	$\|Y_{fs}\|$	8000 10,000	— —	18,000 20,000	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	MFE120,22 MFE121	C_{iss}	— —	4.5 4.5	7.0 6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, f = 1.0 MHz)		C_{rss}	—	0.023	—	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	MFE120,22 MFE121	C_{oss}	— —	2.5 2.5	4.0 3.5	pF

6

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

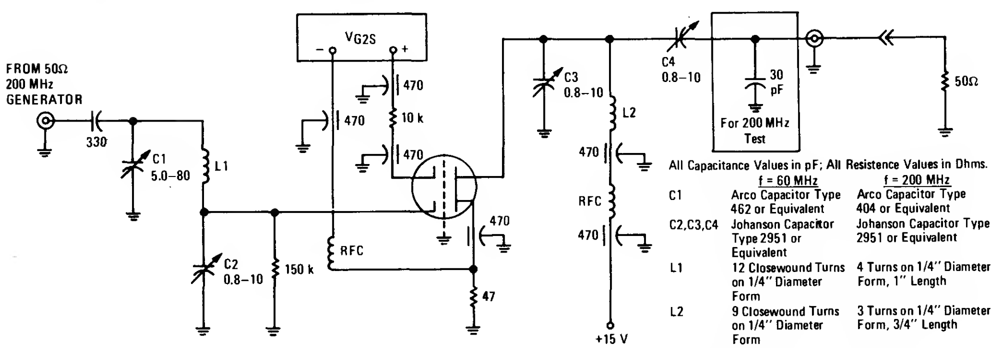
Characteristic		Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF) (f = 105 MHz — Figure 1) (f = 60 MHz — Figure 3) (f = 200 MHz — Figure 3)	 MFE120 MFE121 MFE121	NF	 — — —	 2.9 2.6 2.6	 5.0 5.0 5.0	dB
Common Source Power Gain (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF) (f = 105 MHz — Figure 1) (f = 60 MHz — Figure 3) (f = 200 MHz — Figure 3)	 MFE120 MFE121 MFE121	G_{ps}	 17 20 17	 19.6 27.8 18.6	 — — —	dB
Level of Unwanted Signal for 1.0% Cross Modulation (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)		—	—	100	—	mV
Common-Source Conversion Power Gain (Gate 1 Injection, Figure 2) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, Local Oscillator Voltage = 925 mVrms) (Signal Frequency = 60 MHz, Local Oscillator Frequency = 104 MHz) (Signal Frequency = 200 MHz, Local Oscillator Frequency = 244 MHz)	 MFE122 MFE122	G_c	 15 12	 16.5 13.3	 — —	dB

FIGURE 1 — 105 MHz TEST CIRCUIT



All Capacitance Values in pF; All Resistance Values in Dhms.
L1. 6-1/2 Closewound Turns on 1/4" Diameter Form.
L2: 5 Closewound Turns on 1/4" Diameter Form With Tap 1-1/2 Turns from 8ottom.
C1,C2,C3,C4,C5,C6: Johanson Capacitor Type 2951 or Equivalent
C7: Arco Capacitor Type 404 or Equivalent.
Dverall 8andwidth: 1.3 MHz @ -3.0 d8.

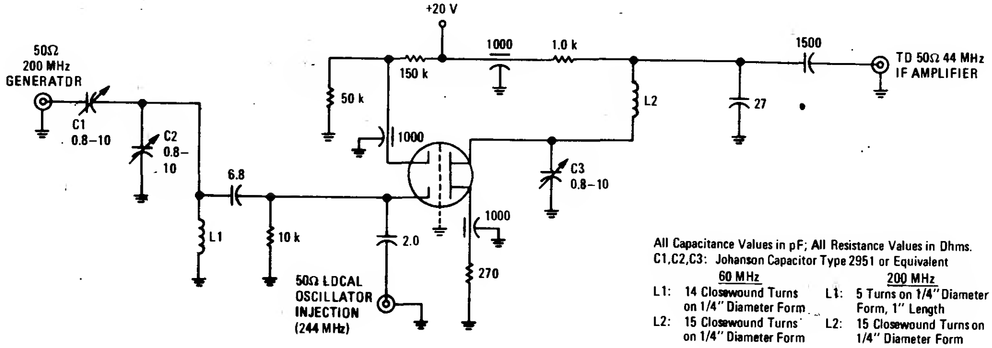
FIGURE 2 — 60 AND 200 MHz TEST CIRCUIT



All Capacitance Values in pF; All Resistence Values in Dhms.

	f = 60 MHz	f = 200 MHz
C1	Arco Capacitor Type 462 or Equivalent	Arco Capacitor Type 404 or Equivalent
C2,C3,C4	Johanson Capacitor Type 2951 or Equivalent	Johanson Capacitor Type 2951 or Equivalent
L1	12 Closewound Turns on 1/4" Diameter Form	4 Turns on 1/4" Diameter Form, 1" Length
L2	9 Closewound Turns on 1/4" Diameter Form	3 Turns on 1/4" Diameter Form, 3/4" Length
RFC	10 μH	1.0 μH
Dverall Bandwidth	6.0 MHz @ -3.0 d8	8.5 MHz @ -3.0 d8

FIGURE 3 – 60 AND 200 MHz CONVERSION POWER GAIN



All Capacitance Values in pF; All Resistance Values in Ohms.
C1,C2,C3: Johanson Capacitor Type 2951 or Equivalent

	60 MHz		200 MHz
L1:	14 Closewound Turns on 1/4" Diameter Form	L1:	5 Turns on 1/4" Diameter Form, 1" Length
L2:	15 Closewound Turns on 1/4" Diameter Form	L2:	15 Closewound Turns on 1/4" Diameter Form

COMMON-SOURCE ADMITTANCE PARAMETERS
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)

FIGURE 4 – INPUT ADMITTANCE

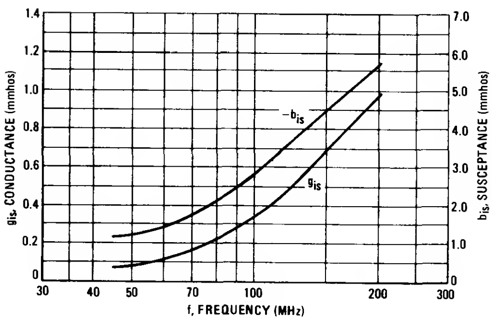


FIGURE 5 – REVERSE TRANSFER ADMITTANCE

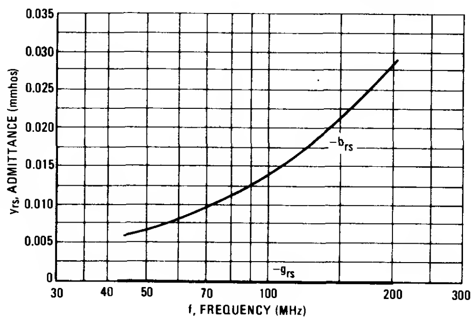


FIGURE 6 – FORWARD TRANSFER ADMITTANCE

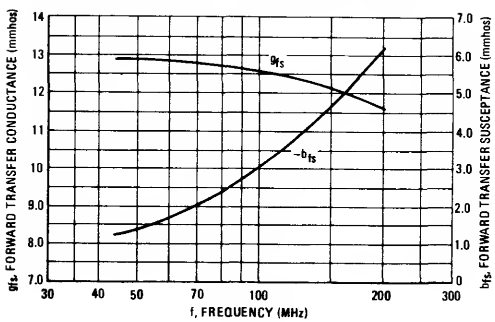


FIGURE 7 – OUTPUT ADMITTANCE

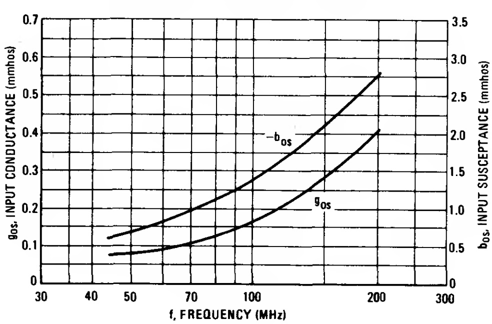


FIGURE 8 – GAIN REDUCTION

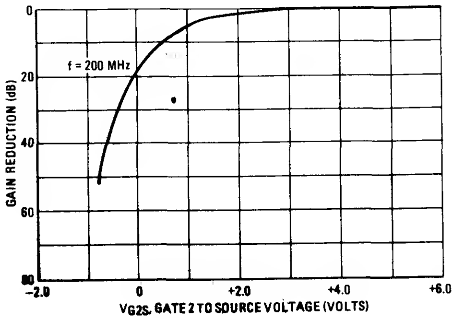
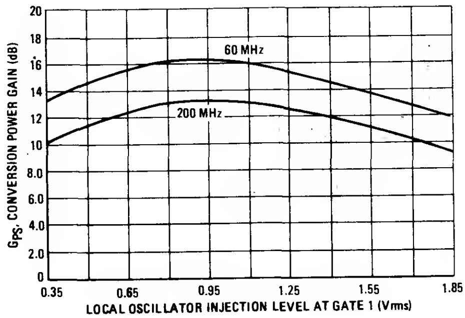


FIGURE 9 – CONVERSION POWER GAIN



6

MFE140

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE MOSFET FM AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	±7.0	Vdc
Drain Current	I_D	30	mAdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300	mW
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1} = −4.0 Vdc, V_{G2} = +4.0 Vdc)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage (I_{G1} = ±10 μAdc, V_{G2S} = 0)	$V_{(BR)G1SO}$	±7.0	—	±20	Vdc
Gate 2-Source Breakdown Voltage (I_{G2} = ±10 μAdc, V_{G2S} = 0)	$V_{(BR)G2SO}$	±7.0	—	±20	Vdc
Gate 1 Leakage Current (V_{G1S} = ±6.0 Vdc, V_{G2S} = 0, V_{DS} = 0)	I_{G1SS}	—	—	20	nAdc
Gate 2 Leakage Current (V_{G2S} = ±6.0 Vdc, V_{G1S} = 0, V_{DS} = 0)	I_{G2SS}	—	—	20	nAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 200 μAdc)	$V_{G1S(off)}$	—	—	−4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 200 μAdc)	$V_{G2S(off)}$	—	—	−4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{G2S} = 0, V_{G2S} = 4.0 Vdc)	I_{DSS}	3.0	10	30	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (Gate 1 connected to Drain) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	10	—	20	mmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, = 1.0 MHz)	C_{rss}	—	0.023	0.05	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{oss}	—	2.5	4.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figure 8) (See Test Circuit in Figure 11)	NF	—	2.5	3.5	dB
Common Source Power Gain (Figure 7) (See Test Circuit in Figure 11)	G_{ps}	20	23	—	dB
Level of Unwanted Signal for 1.0% Cross Modulation (Figure 10) (See Test Circuit in Figure 11)	—	—	45	—	mV

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Common-Source Conversion Power Gain (Gate 1 or Gate 2 Injection, Figure 12) (See Test Circuit in Figure 13) (Signal Frequency = 100 MHz, Local Oscillator Frequency = 110.7 MHz)	G_c	15	18.5	—	dB
1/2 I.F. Rejection (See Test Circuit in Figure 13)	$1/2\ I_{FREJ}$	—	50	—	dB

COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)

FIGURE 1 – INPUT ADMITTANCE

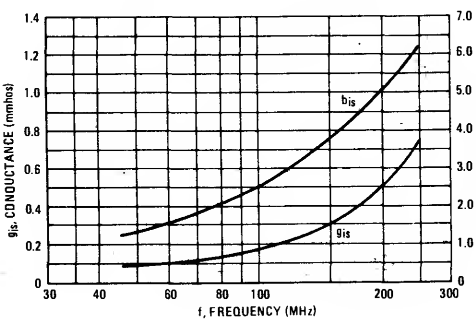


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

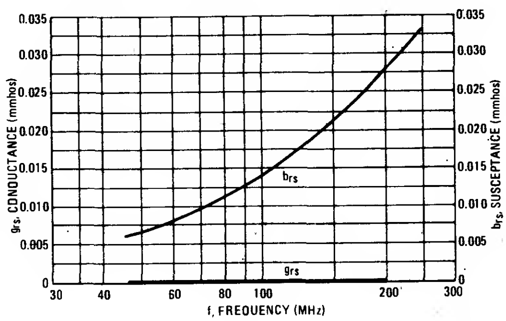


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

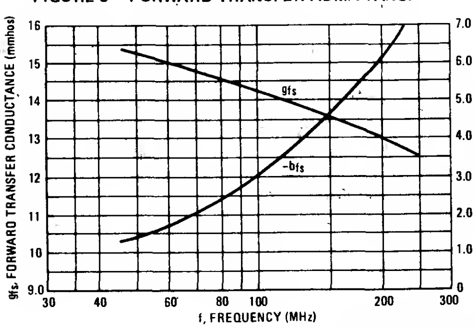
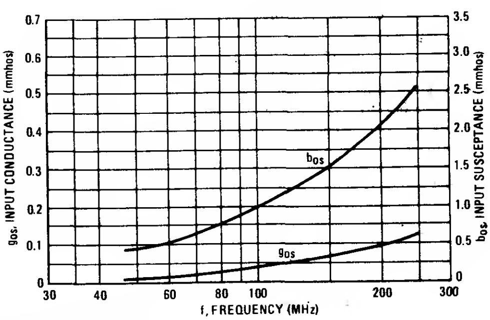


FIGURE 4 – OUTPUT ADMITTANCE



FORWARD TRANSFER ADMITTANCE

(V_{DS} = 15 Vdc, f = 1.0 kHz)

FIGURE 5 – GATE 1

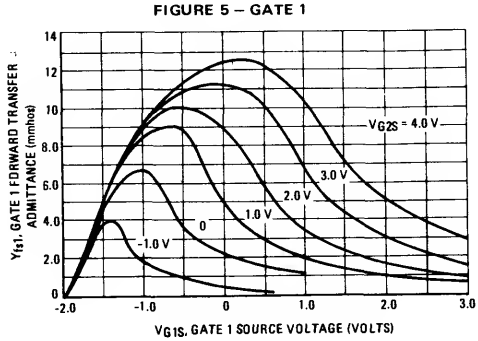


FIGURE 6 – GATE 2

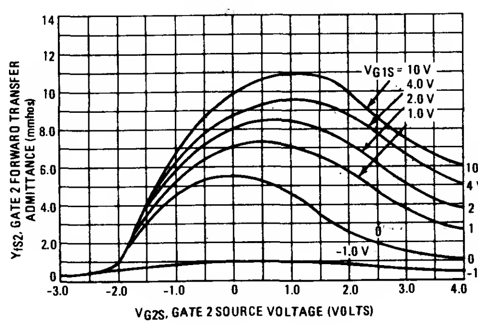


FIGURE 7 – POWER GAIN

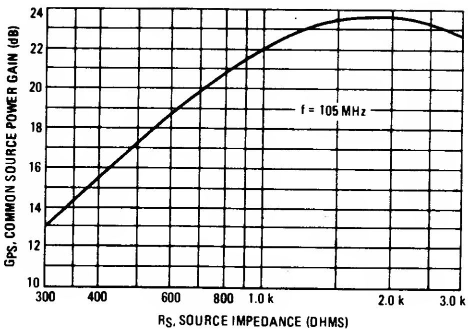


FIGURE 8 – NOISE FIGURE

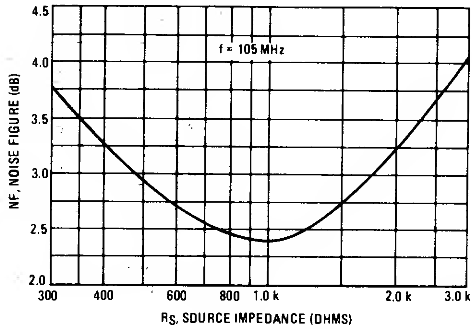


FIGURE 9 – GAIN REDUCTION

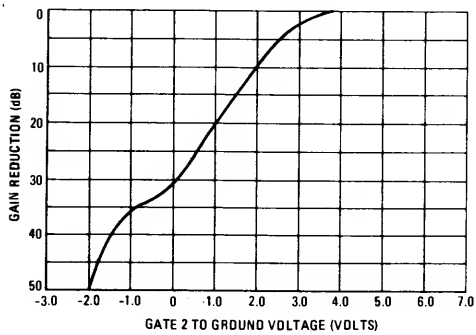


FIGURE 10 – CROSS MODULATION

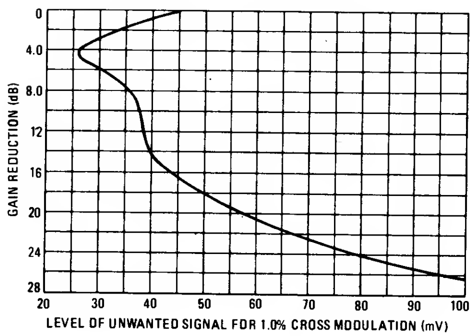
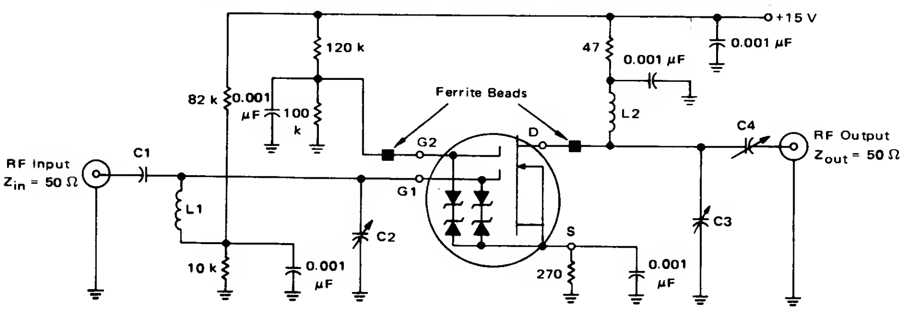


FIGURE 11 – 105 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT

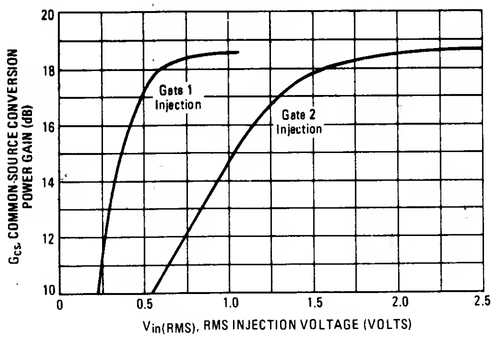


The following component values are for a stern stability factor = 2.0.
L1,L2 126 nH PAUL SMITH CO. SK-138-1
4-½ Turns (yellow)
C1 Nominal 7.0 pF Adjusted for source Impedance of approximately 1000 Ω, JOHANSON JMC2951

C2 Nominal 4.0 pF ARCO 402
C3 Nominal 13.73 pF ARCO 403
C4 Nominal 4.36 pF JOHANSON JMC2951

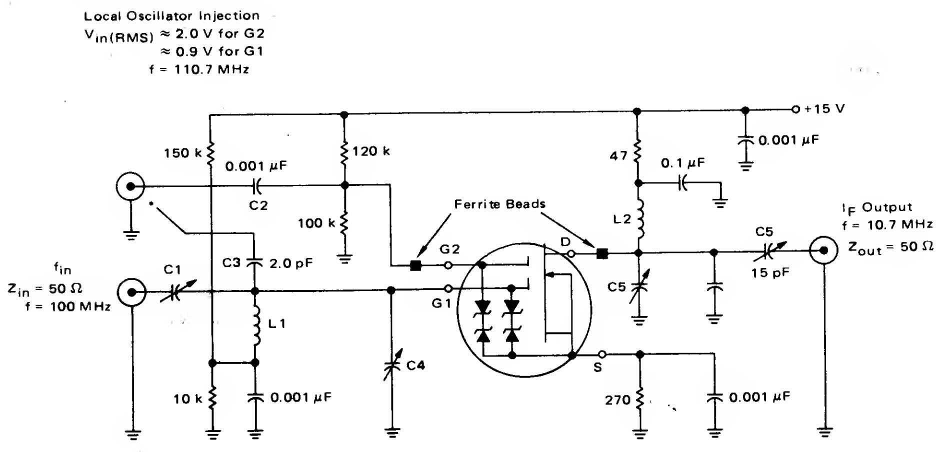
All Decoupling Capacitors are Ceramic Discs.

FIGURE 12 – CONVERSION GAIN



6

FIGURE 13 – CONVERSION GAIN TEST CIRCUIT



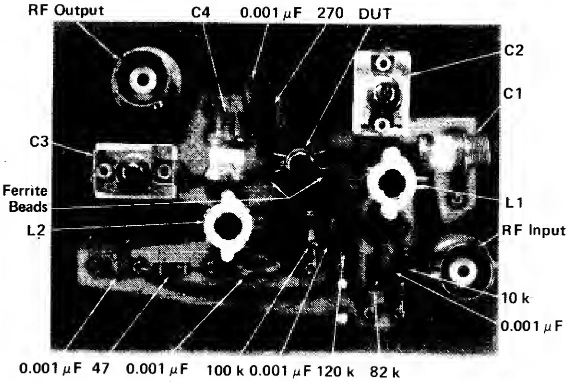
L1 126 nH PAUL SMITH CO. SK-138-1
4-½ Turns (yellow)
L2 2.73 µH High Unloaded Q
C1 JOHANSON JMC2951
C4,C5,C6 ARCO 402

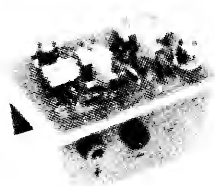
*For G1 Injection, C2 is changed to bypass G2 to ground and C3 is added to connect G1 to the injection input.

PRINTED CIRCUIT BOARD LAYOUT INFORMATION

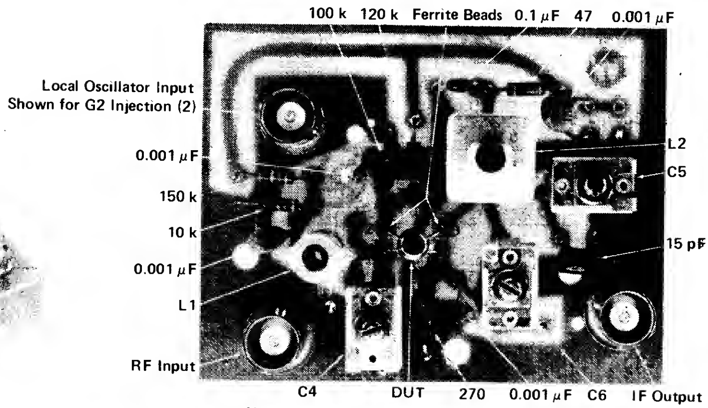
FIGURE 14 – TEST FIXTURES

105 MHz POWER GAIN AND NOISE
FIGURE TEST CIRCUIT





100 MHz to 10.7 MHz CONVERSION
GAIN TEST CIRCUIT



Notes:
1. C1 is on the bottom side of the board.
2. For G1 Injection, C2 is changed to bypass G2 to ground and C3 is added to connect G1 to the injection input. See Figure 13.

MFE823

CASE 22-03, STYLE 11
TO-18 (TO-206AA)

MOSFET

P-CHANNEL — ENHANCEMENT

Refer to 2N4352 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	±10	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	584	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = -10\ \mu Adc$, $V_{GS} = 0$ Vdc)	$V_{(BR)DSX}$	−25	—	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = -10$ Vdc, $V_{GS} = 0$)	I_{DSS}	—	−20	nAdc
Gate Reverse Current ($V_{GS} = -10$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	1.0	pAdc
ON CHARACTERISTICS				
Gate Threshold Voltage ($V_{DS} = -10$ Vdc, $I_D = -10\ \mu Adc$)	$V_{GS(Th)}$	−2.0	−6.0	Vdc
On-State Drain Current ($V_{DS} = -10$ Vdc, $V_{GS} = -10$ Vdc)	$I_{D(on)}$	−3.0	—	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = -10$ Vdc, $I_D = -2.0$ mAdc, f = 1.0 kHz)	$\lvert Y_{fs} \rvert$	1000	—	µmhos
Input Capacitance ($V_{DS} = -10$ Vdc, $V_{GS} = -10$ Vdc, f = 1.0 MHz)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = -10$ Vdc, $V_{GS} = -10$ Vdc, f = 1.0 MHz)	C_{rss}	—	1.5	pF

MFE825

CASE 22-03, STYLE 2
TO-18 (TO-206AA)

MOSFET

N-CHANNEL — DEPLETION

Refer to 2N3796 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	25	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.6	mW mW/°C
Junction Temperature Range	T_J	150	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (I_D = 1.0 μA, V_{GS} = −8.0 V)	$V_{(BR)DSX}$	20	—	Vdc
Gate Reverse Current (V_{GS} = −10 V, V_{DS} = 0 V)	I_{GSS}	—	−1.0	pA
Gate Source Voltage (I_D = 1.0 μA, V_{DS} = 2.0 V)	V_{GS}	0	−2.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	I_{DSS}	1.0	25	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	500	—	μmhos

6

MFE910
MPF910

MFE910
CASE 79-02, STYLE 6
TO-39 (TO-205AD)

MPE910
CASE 29-03, STYLE 22
(TO-226AE)

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to 2N6659 for additional graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Gate-Source Voltage	V_{GS}	±15	Vdc
Drain Current — Continuous(1) Pulsed(2)	I_D I_{DM}	0.5 1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C MPF910	P_D	1.0 8.0	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C MFE910	P_D	6.25 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 40 V, V_{GS} = 0)	I_{DSS}	—	0.1	10	μAdc
Gate Reverse Current (V_{GS} = 10 V, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	60	90	—	Vdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.3	1.5	2.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 500 mA)	$V_{DS(on)}$	—	—	2.5	Vdc
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)	$I_{D(on)}$	500	—	—	mA
Forward Transconductance (V_{DS} = 15 V, I_D = 500 mA)	g_{fs}	100	—	—	mmhos

FIGURE 1 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

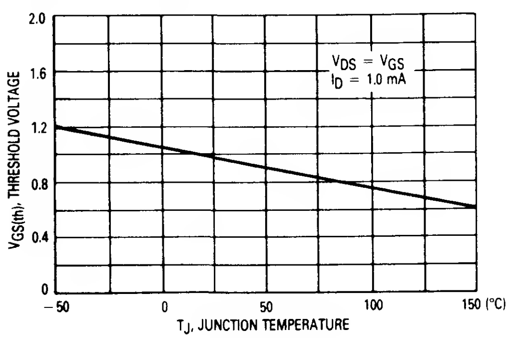


FIGURE 2 — ON-REGION CHARACTERISTICS

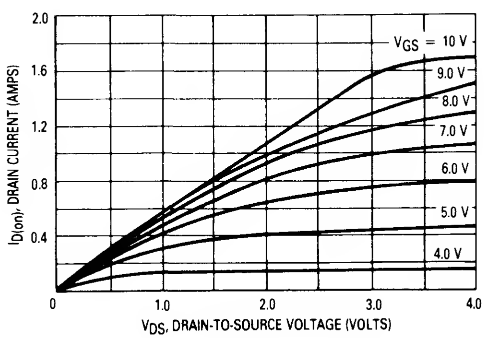


FIGURE 3 — OUTPUT CHARACTERISTICS

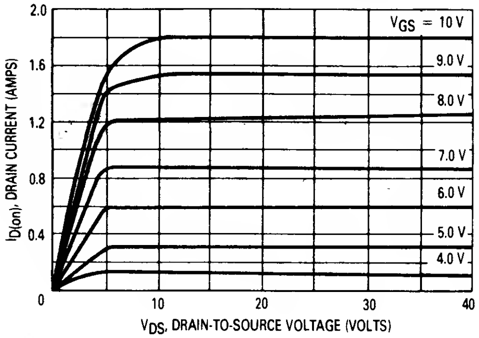
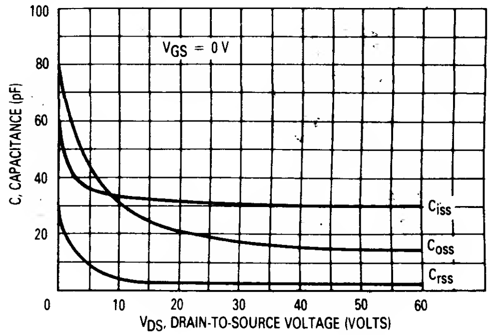


FIGURE 4 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE



6

MFE930
MFE960
MFE990

CASE 79-02, STYLE 6
TO-39 (TO-205AD)

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	MFE930	MFE960	MFE990	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}		±30		Vdc
Drain Current Continuous(1) Pulsed(2)	 I_D I_{DM}		 2.0 3.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		 6.25 50		 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to 150		°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	MFE930 MFE960 MFE990	$V_{(BR)DSX}$	35 60 90	— — —	— — —	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 0.5 A)	MFE930 MFE960 MFE990	$V_{DS(on)}$	— — —	0.4 0.6 0.6	0.7 0.8 1.0	Vdc
(I_D = 1.0 A)	MFE930 MFE960 MFE990		— — —	0.9 1.2 1.2	1.4 1.7 2.0	
(I_D = 2.0 A)	MFE930 MFE960 MFE990		— — —	2.2 2.8 2.8	3.0 3.5 4.0	
Static Drain-Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	MFE930 MFE960 MFE990	$r_{DS(on)}$	— — —	0.9 1.2 1.2	1.4 1.7 2.0	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	60	70	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	13	18	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	49	60	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)	g_{fs}	200	380	—	mmhos
SWITCHING CHARACTERISTICS*					
Turn-On Time (See Figure 1)	t_{on}	—	7.0	15	ns
Turn-Off Time (See Figure 1)	t_{off}	—	7.0	15	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

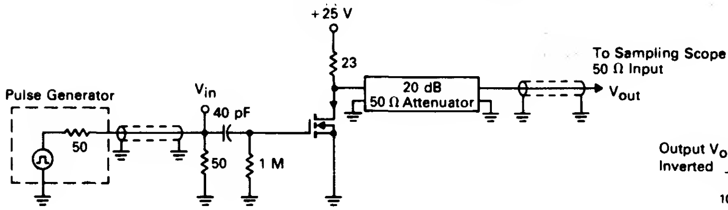


FIGURE 2 — SWITCHING WAVEFORMS

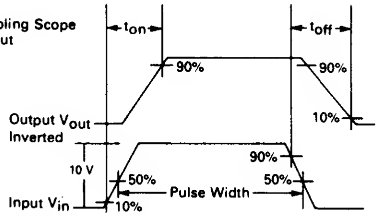


FIGURE 3 — ON VOLTAGE versus TEMPERATURE,

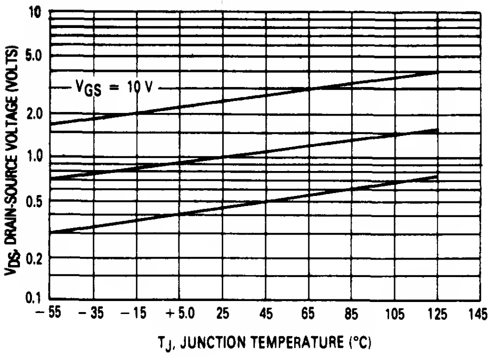


FIGURE 4 — CAPACITANCE VARIATION

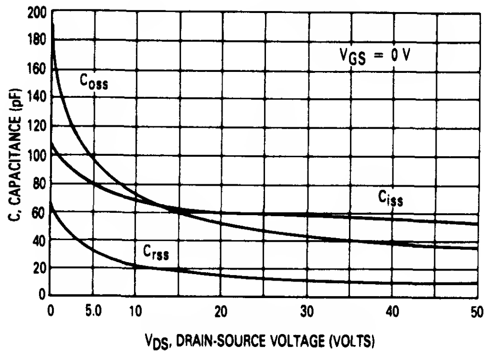


FIGURE 5 — TRANSFER CHARACTERISTIC

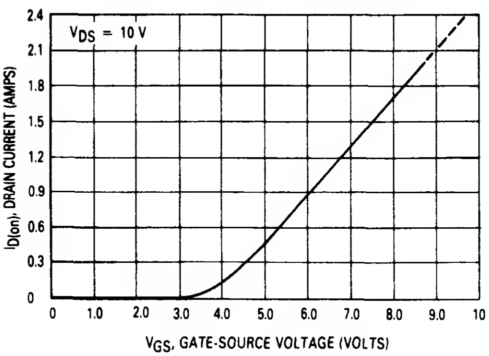


FIGURE 6 — OUTPUT CHARACTERISTIC

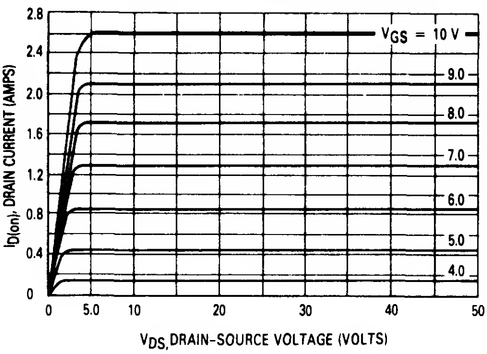
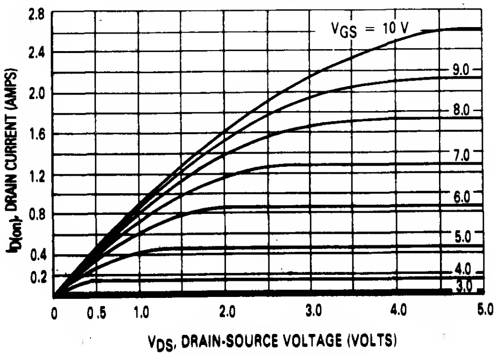


FIGURE 7 — SATURATION CHARACTERISTIC



6

MFE2000
MFE2001

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu$Adc, $V_{DS} = 0$)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current ($V_{GS} = -20$ Vdc, $V_{DS} = 0$) ($V_{GS} = -20$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)		I_{GSS}	 — —	 — —	 −100 −200	 pAdc nAdc
Gate Source Cutoff Voltage ($I_D = 0.5$ mAdc, $V_{DS} = 15$ Vdc)	 MFE2000 MFE2001	$V_{GS(off)}$	 −0.5 −2.0	 — —	 −4.0 −6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	 MFE2000 MFE2001	I_{DSS}	 4.0 8.0	 — —	 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	 MFE2000 MFE2001	$\|y_{fs}\|$	 2500 4000	 — —	 6000 8000	μmhos
Output Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	 MFE2000 MFE2001	$\|y_{os}\|$	 — —	 — —	 50 75	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{rss}	—	—	1.0	pF
Output Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{oss}	—	—	2.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure ($V_{DS} = 15$ Vdc, $I_D = 4.0$ mAdc, f = 100 MHz, $R_G \approx 1.0$ k ohm) ($V_{DS} = 15$ Vdc, $I_D = 4.0$ mAdc, f = 400 MHz, $R_G \approx 1.0$ k ohm)		NF	 — —	 1.6 3.3	 2.0 4.0	dB
Common Source Power Gain ($V_{DS} = 15$ Vdc, $I_D = 4.0$ mAdc, f = 100 MHz) ($V_{DS} = 15$ Vdc, $I_D = 4.0$ mAdc, f = 400 MHz)		G_{ps}	 18 10	 23 14	 — —	dB

MFE2004
MFE2005
MFE2006

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
CHOPPER

N-CHANNEL — DEPLETION

Refer to 2N4091 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 0.2 0.4	 nAdc μAdc
Drain Cutoff Current (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)		$I_{D(off)}$	 — —	 0.2 0.4	 nAdc μAdc
Gate Source Voltage (V_{DS} = 20 Vdc, I_D = 50 μAdc)	 MFE2004 MFE2005 MFE2006	V_{GS}	 1.0 2.0 5.0	 6.0 8.0 10	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 20 Vdc, V_{GS} = 0)	 MFE2004 MFE2005 MFE2006	I_{DSS}*	 8.0 15 30	 — — —	mAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		$V_{GS(f)}$	—	1.0	Vdc
Drain-Source On-Voltage (I_D = 3.0 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 10 mAdc, V_{GS} = 0)	 MFE2004 MFE2005 MFE2006	$V_{DS(on)}$	 — — —	 0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 MFE2004 MFE2005 MFE2006	$r_{DS(on)}$	 — — —	 80 50 30	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 MFE2004 MFE2005 MFE2006	$r_{ds(on)}$	 — — —	 80 50 30	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{iss}	—	16	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = 6.0 Vdc, f = 1.0 MHz)	MFE2004		—	5.0	
(V_{DS} = 0, V_{GS} = 8.0 Vdc, f = 1.0 MHz)	MFE2005		—	5.0	
(V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)	MFE2006		—	5.0	
SWITCHING CHARACTERISTICS					
Turn-On Delay Time		$t_{d(on)}$			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004		—	20	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		—	15	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, V_{GS} = 0)	MFE2006		—	10	
Rise Time		t_r			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004		—	40	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		—	20	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, V_{GS} = 0)	MFE2006		—	10	
Turn-Off Time		t_{off}			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, $V_{GS(off)}$ = 6.0 Vdc)	MFE2004		—	80	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, $V_{GS(off)}$ = 8.0 Vdc)	MFE2005		—	60	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MFE2006		—	40	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

6

MFE2010
MFE2011
MFE2012

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
CHOPPER

N-CHANNEL — DEPLETION

Refer to J107 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watt mW/°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 3.0 6.0	 nAdc μAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)		$I_{D(off)}$	 — —	 3.0 6.0	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 20 Vdc, V_{GS} = 0)	 MFE2010 MFE2011 MFE2012	I_{DSS}*	 15 40 100	 — — —	mAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		$V_{GS(f)}$	—	1.0	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	 MFE2010 MFE2011 MFE2012	V_{GS}	 0.5 1.0 3.0	 10 10 10	Vdc
Drain-Source On-Voltage (I_D = 8.0 mAdc, V_{GS} = 0) (I_D = 15 mAdc, V_{GS} = 0) (I_D = 30 mAdc, V_{GS} = 0)	 MFE2010 MFE2011 MFE2012	$V_{DS(on)}$	 — — —	 0.75 0.75 0.75	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 MFE2010 MFE2011 MFE2012	$r_{DS(on)}$	 — — —	 25 15 10	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 MFE2010 MFE2011 MFE2012	$r_{ds(on)}$	 — — —	 25 15 10	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)		C_{iss}	—	50	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)		C_{rss}	—	20	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Delay Time		$t_{d(on)}$	—	10	ns
Rise Time		t_r	—	6.0	ns
Turn-Off Delay Time		$t_{d(off)}$			ns
(V_{DD} = 15 Vdc, I_D = 8.0 mAdc)	MFE2010		—	35	
(V_{DD} = 15 Vdc, I_D = 15 mAdc)	MFE2011		—	20	
(V_{DD} = 15 Vdc, I_D = 30 mAdc)	MFE2012		—	12	
Fall Time		t_f			ns
(V_{DD} = 15 Vdc, I_D = 8.0 mAdc)	MFE2010		—	75	
(V_{DD} = 15 Vdc, I_D = 15 mAdc)	MFE2011		—	45	
(V_{DD} = 15 Vdc, I_D = 30 mAdc)	MFE2012		—	25	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

MFE3001

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

FET
LOW-POWER AUDIO

N-CHANNEL — DEPLETION

Refer to 2N3796 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	±20	Vdc
Drain Current	I_D	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Junction Temperature Range	T_J	+200	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = −8.0 V, I_D = 10 μAdc)	$V_{(BR)DSX}$	20	—	Vdc
Gate Reverse Current (V_{GS} = −10 Vdc, V_{DS} = 0)	I_{GSS}	—	10	pAdc
Gate Source Cutoff Voltage (I_{DS} = 1.0 μAdc, V_{DS} = 10 Vdc)	$V_{GS(off)}$	—	−8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{GS} = 0 Vdc, V_{DS} = 10 Vdc)	I_{DSS}	0.5	6.0	mAdc
On-State Drain Current (V_{GS} = 3.5 Vdc, V_{DS} = 10 Vdc)	$I_{D(on)}$	5.0	—	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}\|$	700	3500	μmhos
Output Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	100	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.5	pF

MFE3002

CASE 20-03, STYLE 7
TO-72 (TO-206AF)

MOSFET
CHOPPER

N-CHANNEL — ENHANCEMENT

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	15	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	200 1.4	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = +10$ Vdc, $V_{GS} = 0$) ($V_{DS} = +10$ Vdc, $V_{GS} = 0$, $T_C = 125°C$)	I_{DSS}	 — —	 10 100	nAdc
Gate Reverse Current ($V_{GS} = \pm 10$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	±100	pAdc
Drain-Source Breakdown Voltage ($V_{GS} = 0$, $I_D = 10\ \mu$Adc)	$V_{(BR)DS}$	15	—	Vdc
ON CHARACTERISTICS				
Gate Threshold Voltage ($V_{DS} = +10$ Vdc, $I_D = 10\ \mu$Adc)	$V_{GS(TH)}$	—	3.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Input Capacitance ($V_{DS} = +10$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Drain-Substrate Capacitance ($V_{D(SUB)} = +10$ Vdc, f = 1.0 MHz)	$C_{d(sub)}$	—	4.0	pF
Static Drain-Source On Resistance ($V_{GS} = +10$ Vdc, $I_D = 0$, f = 1.0 kHz)	$r_{ds(on)}$	—	100	Ohms

MFE3003

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

MOSFET CHOPPER

P-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−15	Vdc
Drain-Gate Voltage	V_{DG}	±20	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.33	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = −10 μAdc)	$V_{(BR)DSX}$	−15	—	Vdc
Zero-Gate-Voltage Drain Current (V_{DS} = −10 Vdc, V_{GS} = 0) (V_{DS} = −10 Vdc, V_{GS} = 0, T_C = 125°C)	I_{DSS}	 — —	 −10 −100	nAdc
Gate Reverse Current (V_{GS} = ±10 Vdc, V_{DS} = 0)	I_{GSS}	—	±100	pAdc
ON CHARACTERISTICS				
Gate Threshold Voltage (V_{DS} = −10 Vdc, I_D = −10 μAdc)	$V_{GS(Th)}$	—	−4.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance (V_{GS} = −10 Vdc, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	—	200	Ohms
Input Capacitance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = −10 Vdc, f = 1.0 MHz)	$C_{d(sub)}$	—	2.0	pF

MFE3004
MFE3005

CASE 20-03, STYLE 7
TO-72 (TO-206AF)

MOSFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	200 1.33	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($V_{GS} = -5.0$ Vdc, $I_D = 10$ μAdc)	$V_{(BR)DSX}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = \pm 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	±50	pAdc
Gate Source Cutoff Voltage ($I_D = 10$ μAdc, $V_{DS} = 15$ Vdc)	$V_{GS(off)}$	—	−5.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	2.0	10	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $I_D = 2.0$ mAdc, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	2000	—	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	4.5	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	0.4	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure	NF			dB
($V_{DS} = 15$ Vdc, $I_D = 2.0$ mAdc, $R_S \approx 1.8$ k ohms, f = 200 MHz) (Figure 1) MFE3004		—	4.5	
($V_{DS} = 15$ Vdc, $I_D = 2.0$ mAdc, $R_S \approx 650$ ohms, f = 400 MHz) (Figure 2) MFE3005		—	4.5	
Common Source Power Gain	G_{ps}			dB
($V_{DS} = 15$ Vdc, $I_D = 2.0$ mAdc, $R_S \approx 1.8$ k ohms, f = 200 MHz) (Figure 1) MFE3004		16	—	
($V_{DS} = 15$ Vdc, $I_D = 2.0$ mAdc, $R_S \approx 650$ ohms, f = 400 MHz) (Figure 2) MFE3005		10	—	

FIGURE 1 - 200 MHz TEST CIRCUIT - NEUTRALIZED

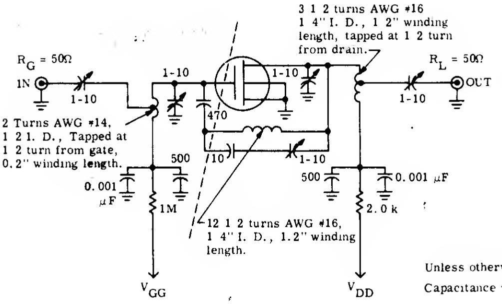
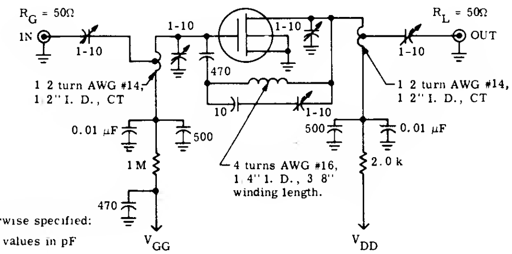


FIGURE 2 - 400 MHz TEST CIRCUIT - NEUTRALIZED



Unless otherwise specified:
Capacitance values in pF

MFE9200

CASE 22-03, STYLE 12
TO-18 (TO-206AA)

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	200	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current Continuous (1) Pulsed (2)	 I_D I_{DM}	 400 800	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 14.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	$V_{(BR)DSX}$	200	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	0.01	50	nAdc
ON CHARACTERISTICS*					
Zero-Gate-Voltage Drain Current (V_{DS} = 200 V, V_{GS} = 0)	I_{DSS}	—	0.1	10	μAdc
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(Th)}$	1.0	—	4.0	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 100 mA) (I_D = 250 mA) (I_D = 500 mA)	$V_{DS(on)}$	 — — —	 0.45 1.20 3.0	 0.6 1.60 —	Vdc
Static Drain-Source On Resistance (V_{GS} = 10 Vdc) (I_D = 100 mA) (I_D = 250 mA) (I_D = 500 mA)	$r_{DS(on)}$	 — — —	 4.5 4.8 6.0	 6.0 6.4 —	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)	$I_{D(on)}$	400	700	—	mA
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	72	90	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	2.8	3.5	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	15	20	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 250 mA)	g_{fs}	200	400	—	mmhos
SWITCHING CHARACTERISTICS					
Turn-On Time See Figure 1	t_{on}	—	6.0	15	ns
Turn-Off Time See Figure 1	t_{off}	—	6.0	15	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

6

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

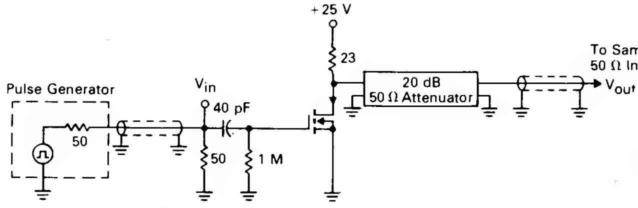


FIGURE 2 — SWITCHING WAVEFORMS

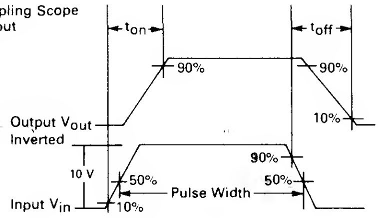


FIGURE 3 — ON VOLTAGE versus TEMPERATURE

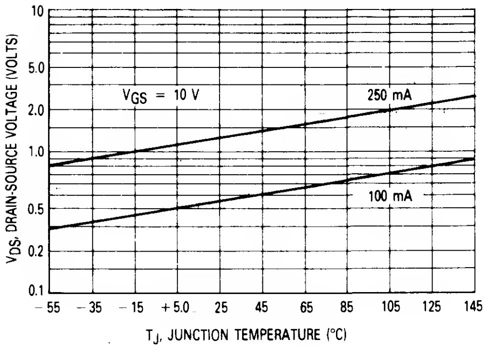


FIGURE 4 — CAPACITANCE VARIATION

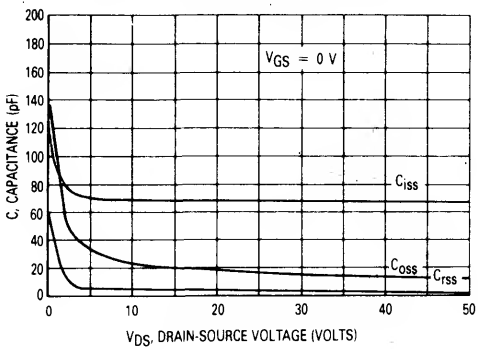


FIGURE 5 — TRANSFER CHARACTERISTIC

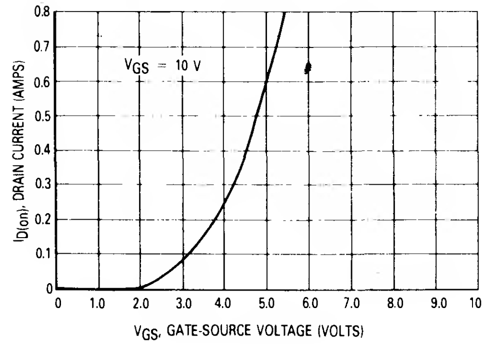


FIGURE 6 — OUTPUT CHARACTERISTIC

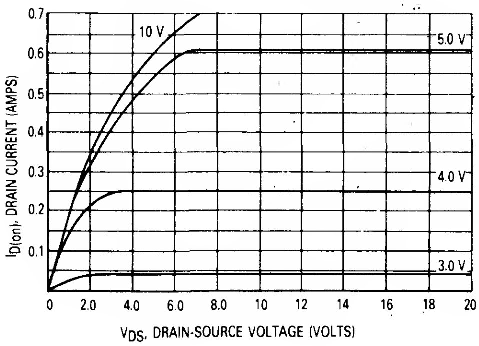
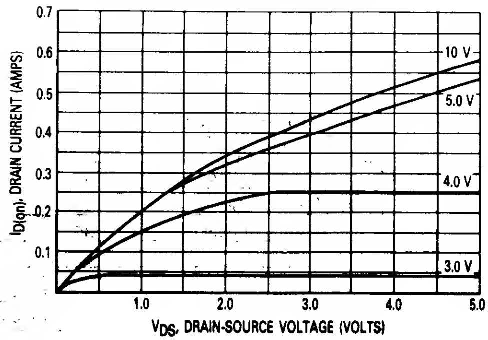


FIGURE 7 — SATURATION CHARACTERISTIC



6

MFQ107

CASE 646-05, STYLE 1

QUAD DUAL IN LINE TMOS

N-CHANNEL — ENHANCEMENT

Refer to MFE9200 for graphs

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Drain-Source Voltage	V_{DS}	200		Vdc
Drain-Gate Voltage	V_{DG}	200		Vdc
Gate-Source Voltage	V_{GS}	±20		Vdc
Drain Current	I_D	400		mAdc
		Each Transistor	**Four Transistors Equal Power**	
Total Device Dissipation @ $T_A = 25°C$ (1) Derate above 25°C	P_D	0.5 4.0	1.2 9.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($V_{GS} = 0$, $I_D = 10\ \mu A$)	$V_{(BR)DSS}$	200	—	—	Vdc
Zero Gate Voltage Drain Current ($V_{DS} = 130$ V, $V_{GS} = 0$)	I_{DSS}	—	0.1	10	μAdc
Gate-Body Leakage Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	0.01	50	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage ($I_D = 1.0$ mA, $V_{DS} = V_{GS}$)	$V_{GS(th)}$	1.0	—	4.0	Vdc
Static Drain-Source On-Resistance ($V_{GS} = 10$ Vdc) ($I_D = 100$ mA) ($I_D = 250$ mA) ($V_{GS} = 2.6$ V, $I_D = 20$ mA)	$r_{DS(on)}$	 — — —	 4.5 4.8 	 15 15 30	Ohms
Drain-Source On-Voltage ($V_{GS} = 10$ V) ($I_D = 100$ mA) ($I_D = 250$ mA) ($I_D = 500$ mA)	$V_{DS(on)}$	 — — —	 0.45 1.20 3.0	 1.5 3.75 —	Vdc
Forward Transconductance ($V_{DS} = 25$ V, $I_D = 250$ mA)	g_{fs}	200	400	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance ($V_{DS} = 25$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	72	90	pF
Output Capacitance ($V_{DS} = 25$ V, $V_{GS} = 0$, f = 1.0 MHz	C_{oss}	—	15	20	pF
Reverse Transfer Capacitance ($V_{DS} = 25$ V, $V_{GS} = 0$, f = 1.0 MHz	C_{rss}	—	2.8	3.5	pF
SWITCHING CHARACTERISTICS*					
Turn-On Time See Figure 1	t_{on}	—	6.0	15	ns
Turn-Off Time See Figure 1	t_{off}	—	12	15	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

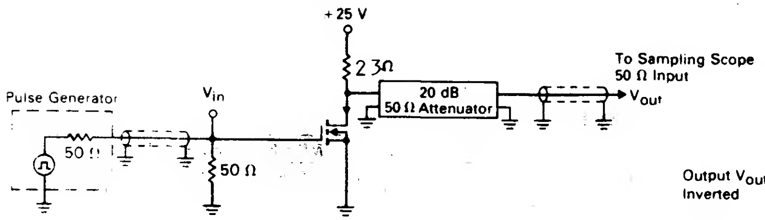
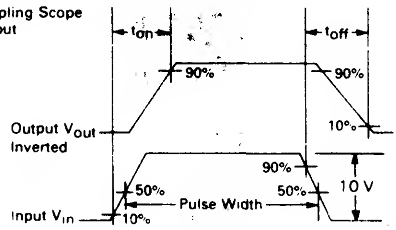


FIGURE 2 — SWITCHING WAVEFORMS



MFQ930C
MFQ960C
MFQ990C

CASE 632-02, STYLE 1
TO-116

QUAD
DUAL-IN-LINE
TMOS

N-CHANNEL — ENHANCEMENT

Refer to MFE930 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	MFQ930C	MFQ960C	MFQ990C	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}		±30		Vdc
Drain Current Continuous (1) Pulsed (2)	 I_D I_{DM}		 2.0 3.0		Adc
			Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D		0.5 17.0	2.0 66.6	Watts mW/°C
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−55 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	MFQ930C MFQ960C MFQ990C	$V_{(BR)DSX}$	35 60 90	— — —	— — —	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})		$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 0.5 A)	MFQ930C MFQ960C MFQ990C	$V_{DS(on)}$	— — —	0.4 0.6 0.6	0.7 0.8 1.0	Vdc
(I_D = 1.0 A)	MFQ930C MFQ960C MFQ990C		— — —	0.9 1.2 1.2	1.4 1.7 2.0	
(I_D = 2.0 A)	MFQ930C MFQ960C MFQ990C		— — —	2.2 2.8 2.8	3.0 3.5 4.0	
Static Drain-Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	MFQ930C MFQ960C MFQ990C	$r_{DS(on)}$	— — —	0.9 1.2 1.2	1.4 1.7 2.0	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	60	70	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	13	18	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	49	60	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{fs}	200	380	—	mmhos
SWITCHING CHARACTERISTICS						
Turn-On Time		t_{on}	—	7.0	15	ns
Turn-Off Time		t_{off}	—	7.0	15	ns

MPF102

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}	 — —	 −2.0 −2.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 2.0 nAdc)	$V_{GS(off)}$	—	−8.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.2 mAdc)	V_{GS}	−0.5	−7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	2.0	20	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\|y_{fs}\|$	 2000 1600	 7500 —	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	—	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	—	200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	3.0	pF

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

6

MPF108

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	−65 to +135	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}	— —	1.0 −1.0	nAdc μAdc
Gate-Source Cutoff Voltage* (V_{DS} = 15 Vdc, I_D = 10 μAdc)	$V_{GS(off)}$*	0.5	8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	1.5	24	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\|y_{fs}\|$	1600	—	μmhos
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{fs}*	2000	7500	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	—	800	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	—	200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	6.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	2.5	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz) (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 k ohm, f = 100 MHz)	NF	 — —	 2.5 3.0	dB

*To characterize these devices to narrower limits, regarding I_{DSS}, $V_{GS(off)}$ and y_{fs}, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	I_{DS}	$V_{GS(off)}$	Y_{fs}
Orange	1.5 mAdc, Min, 3.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μmhos
Yellow	2.5 mAdc Min, 5.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μmhos
Green	4.0 mAdc Min, 8.0 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μmhos
Blue	7.0 mAdc Min, 14 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μmhos
Violet	12 mAdc Min, 24 mAdc Max	2.0 Vdc Min, 8.0 Vdc Max	3000 to 7500 μmhos

MPF130,131,132
MFE130,131,132

MPF130 SERIES
CASE 317-01, STYLE 1

MFE130 SERIES
CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE MOSFET VHF AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Drain-Source Voltage	V_{DS}	25		Vdc
Drain Current	I_D	30		mAdc
		MPF130 Series	MFE130 Series	
Total Device Dissipation @ T_A = 25°C (Package Limitation) Derate above 25°C	P_D	300 2.4	300 1.71	mW mW/°C
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	−65 to +150	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1} = −4.0 V, V_{G2} = +4.0 V)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage (I_{G1} = ±10 μAdc, V_{G2S} = 0)	$V_{(BR)G1SO}$	±7.0	—	±20	Vdc
Gate 2-Source Breakdown Voltage (I_{G2} = ±10 μAdc, V_{G2S} = 0)	$V_{(BR)G2SO}$	±7.0	—	±20	Vdc
Gate 1 Leakage Current (V_{G1S} = ±6.0 Vdc, V_{G2S} = 0, V_{DS} = 0)	I_{G1SS}	—	—	20	nAdc
Gate 2 Leakage Current (V_{G2S} = ±6.0 Vdc, V_{G1S} = 0, V_{DS} = 0)	I_{G2SS}	—	—	20	nAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 200 μAdc)	$V_{G1S(off)}$	—	—	−4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 200 μAdc)	$V_{G2S(off)}$	—	—	−4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)	I_{DSS}	3.0	10	30	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (Gate 1 connected to Drain) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	8000	—	20000	μmhos
Input Capacitance (V_{DS} = 15 Vdc V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, f = 1.0 MHz)	C_{rss}	—	0.023	0.05	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{oss}	—	2.5	4.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figure 7) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF)	NF				dB
(f = 105 MHz) MPF/MFE130		—	2.9	5.0	
(f = 60 MHz) MPF/MFE131		—	2.5	5.0	
(f = 100 MHz) MPF/MFE131		—	3.0	5.0	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common Source Power Gain (Figure 7) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF)		G_{ps}				dB
(f = 105 MHz)	MPF/MFE130		17	23	—	
(f = 60 MHz)	MPF/MFE131		20	27	—	
(f = 200 MHz)	MPF/MFE131		17	20	—	
Level of Unwanted Signal for 1.0% Cross Modulation (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)		—	—	100	—	mV
Common-Source Conversion Power Gain (Gate 1 Injection, Figure 8) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, Local Oscillator Voltage = 925 mVrms)		G_c				dB
(Signal Frequency = 60 MHz, Local Oscillator Frequency = 104 MHz)	MPF/MFE132		15	16.5	—	
(Signal Frequency = 200 MHz, Local Oscillator Frequency = 244 MHz)	MPF/MFE132		12	14	—	

COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)

FIGURE 1 — INPUT ADMITTANCE

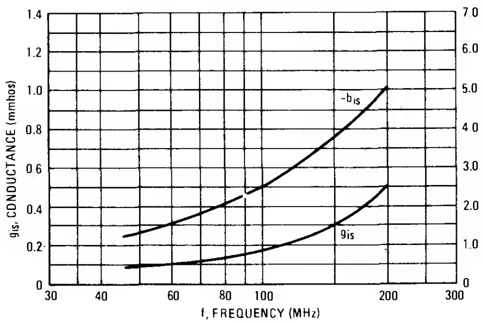


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

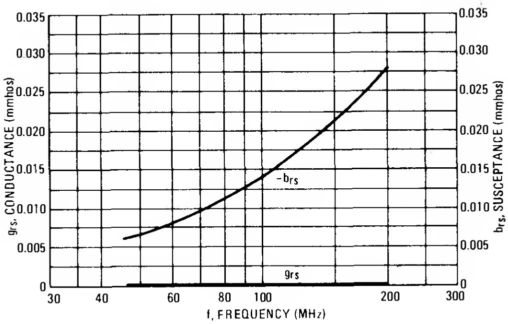


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

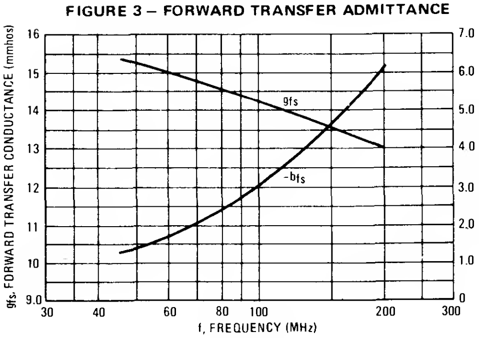


FIGURE 4 — OUTPUT ADMITTANCE

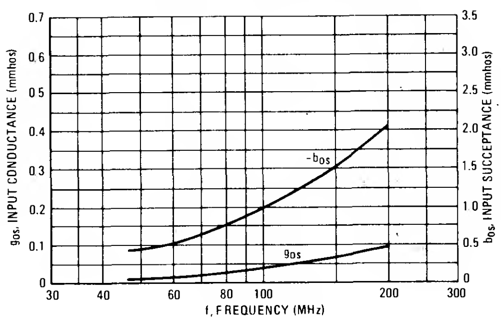


FIGURE 5 – GAIN REDUCTION

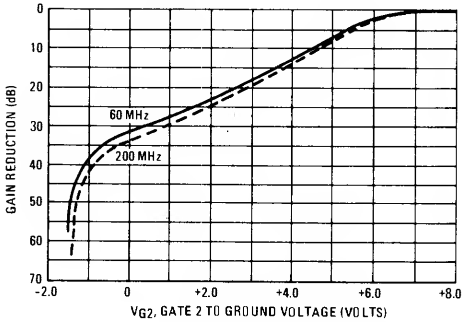


FIGURE 6 – CONVERSION POWER GAIN

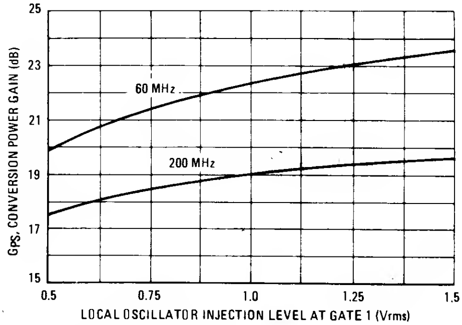
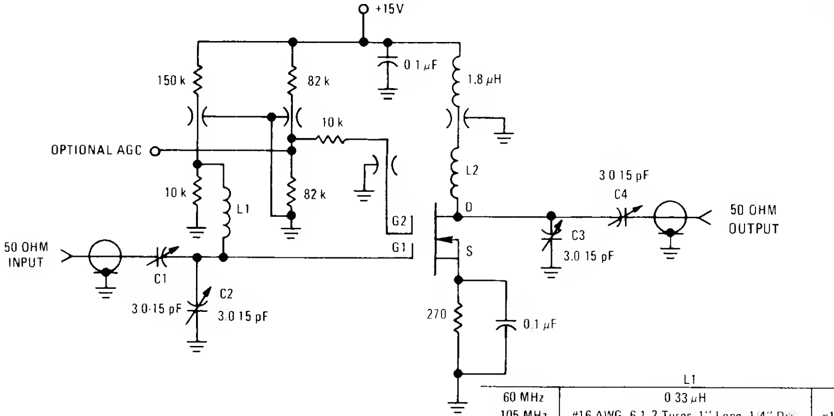


FIGURE 7 – 60, 105 AND 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT

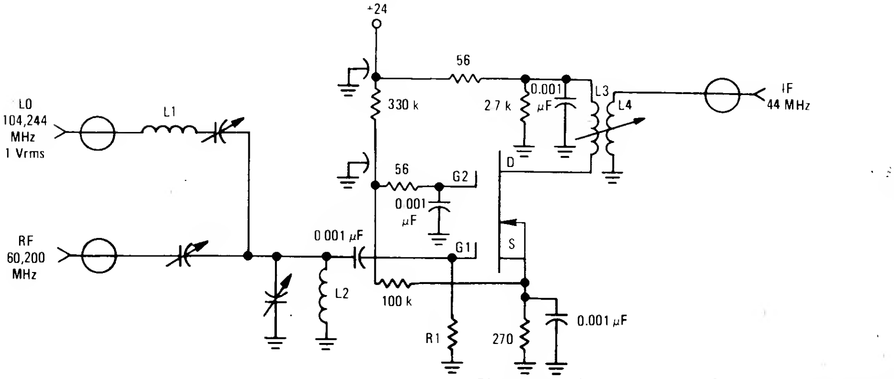


	L1	L2
60 MHz	0.33 μH	0.47 μH
105 MHz	#16 AWG 6 1/2 Turns, 1" Long, 1/4" Dia	#16 AWG, 5 1/4 Turns, 1" Long, 7/16" Dia
200 MHz	#16 AWG, 3 1/2 Turns, 0.7" Long, 0.2" Dia	#16 AWG, 4 1/2 Turns, 0.65" Long, 0.2" Dia.

All Feedthrough Capacitors 1000 pF

All Variable Capacitors JOHANSON JMC2951, 3.0-15 pF

FIGURE 8 – 60 AND 200 MHz CONVERSION GAIN TEST CIRCUIT



	R1	L1	L2	L3	L4
60 MHz	10 k	10 Turns #22 Enameled on MILLER 4500-4 Core	0.33 μH DELEVAN	15 Turns #26 Enameled on MILLER 4500-1 Core	4 Turns #26 Enameled on Same Core as L3
200 MHz	1.0 k	3 1/2 Turns #18, 1/4" Dia., 1/2" Long	2 1/2 Turns #18, 3/8" Dia., 1/2" Long	15 Turns #26 Enameled on MILLER 4500-1 Core	4 Turns #26 Enameled on Same Core as L3

All Feedthrough Capacitors 1000 pF.

All Variable Capacitors JOHANSON JMC2951, 3.0-15 pF.

MPF201
MPF202
MPF203

CASE 317-01, STYLE 1

DUAL-GATE MOSFET VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30	Vdc
Drain Current	I_D	50	mAdc
Gate Current	I_{G1} I_{G2}	±10 ±10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 8.0	Watt mW/°C
Lead Temperature	T_L	260	°C
Junction Temperature Range	T_J	−65 to +150	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

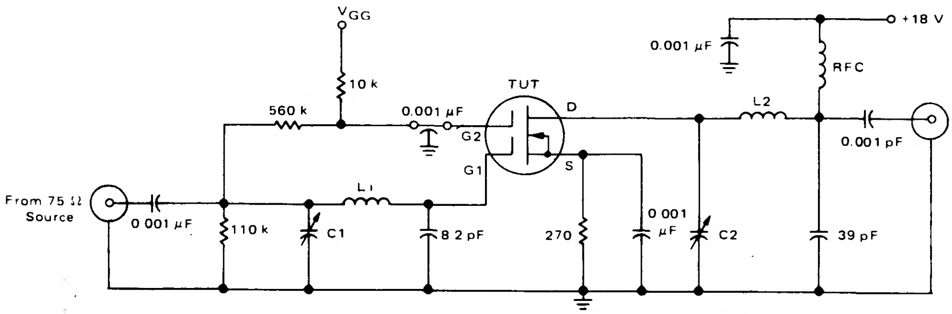
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1S} = V_{G2S} = −5.0 Vdc)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage(1) (I_{G1} = ±10 mAdc, V_{G2S} = V_{DS} = 0)	$V_{(BR)G1SO}$	±6.0	±12	±30	Vdc
Gate 2-Source Breakdown Voltage(1) (I_{G2} = ±10 mAdc, V_{G1S} = V_{DS} = 0)	$V_{(BR)G2SO}$	±6.0	±12	±30	Vdc
Gate 1 Leakage Current (V_{G1S} = ±5.0 Vdc, V_{G2S} = V_{DS} = 0) (V_{G1S} = −5.0 Vdc, V_{G2S} = V_{DS} = 0, T_A = 150°C)	I_{G1SS}	 — —	 ±0.040 —	 ±100 −100	 nAdc μAdc
Gate 2 Leakage Current (V_{G2S} = ±5.0 Vdc, V_{G1S} = V_{DS} = 0) (V_{G2S} = −5.0 Vdc, V_{G1S} = V_{DS} = 0, T_A = 150°C)	I_{G2SS}	 — —	 ±0.050 —	 ±100 −100	 nAdc μAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 20 μAdc)	$V_{G1S(off)}$	−0.5	−1.5	−5.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 20 μAdc)	$V_{G2S(off)}$	−0.2	−1.4	−5.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(2) (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 4.0 Vdc) MPF201, MPF202 MPF203	I_{DSS}	 6.0 3.0	 13 11	 30 15	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(3) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, V_{G1S} = 0, f = 1.0 kHz) MPF201, MPF202 MPF203	$\|Y_{fs}\|$	 8.0 7.0	 12.8 12.5	 20 15	mmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{iss}	—	3.3	—	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{rss}	0.005	0.014	0.05	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{oss}	—	1.7	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1) MPF201 (V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3) MPF203	NF	 — —	 1.8 5.3	 5.0 6.0	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common Source Power Gain		G_{ps}				dB
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	MPF201		15	20	25	
(V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3)	MPF203		20	25	30	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz) (Figure 2)	MPF202	G_c(5)	15	19	25	
Bandwidth		BW				MHz
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	MPF201		5.0	—	9.0	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz) (Figure 2)	MPF202		4.5	—	7.5	
(V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3)	MPF203		3.0	—	6.0	
Gain Control Gate-Supply Voltage(4)		$V_{GG(GC)}$				Vdc
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 200 MHz) (Figure 1)	MPF201		0	−1.0	−3.0	
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 45 MHz) (Figure 3)	MPF203		0	−0.6	−3.0	

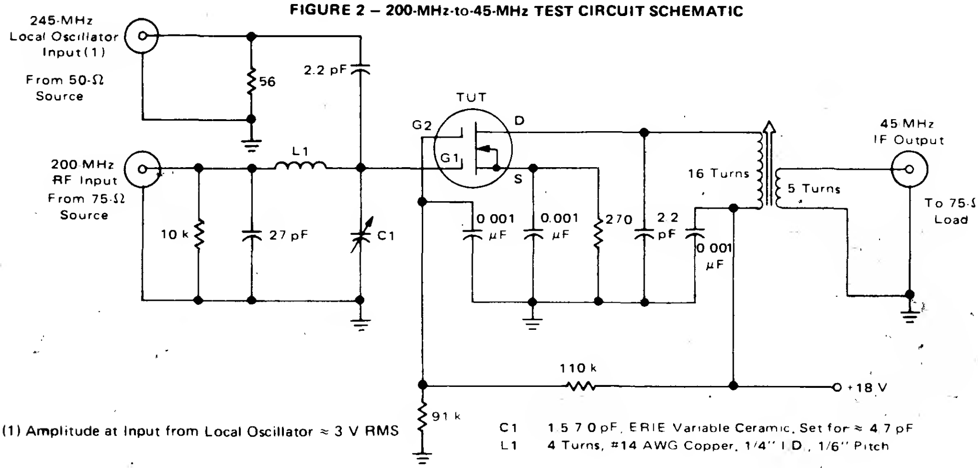
(1) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage limiting network is functioning properly.
(2) Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤ 2.0%.
(3) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.
(4) ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7.0 volts (MPF201) and V_{GG} = 6.0 volts (MPF203).
(5) Power Gain Conversion

FIGURE 1 — 200-MHz TEST CIRCUIT SCHEMATIC



C1 4.0-?? pF, ERIE Variable Ceramic, Set for ≈ 22 pF
C2 4.0-30 pF, ERIE Variable Ceramic, Set for ≈ 10 pF
L1 4 Turns, #14 AWG Cooper, 1/4" I.D., 1/6" Pitch
L2 3 Turns, #14 AWG Cooper, 1/4" I.D., 1/8" Pitch
RFC DELEVAN No. 153712, 1.0 µH

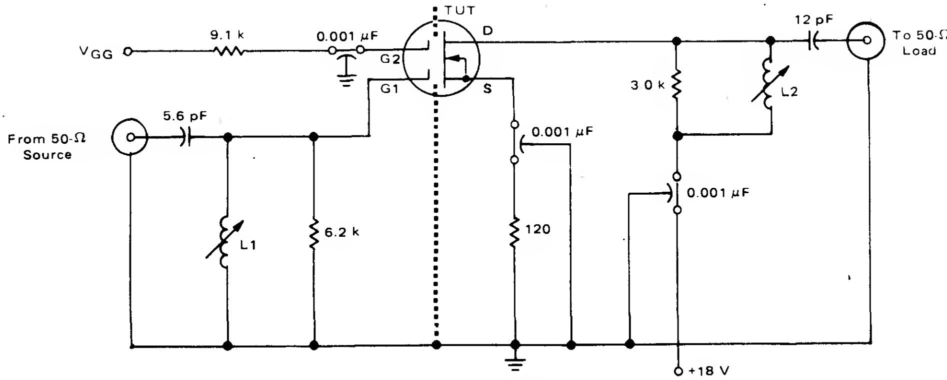
FIGURE 2 — 200-MHz-to-45-MHz TEST CIRCUIT SCHEMATIC



(1) Amplitude at Input from Local Oscillator ≈ 3 V RMS

C1 1.5-7.0 pF, ERIE Variable Ceramic, Set for ≈ 4.7 pF
L1 4 Turns, #14 AWG Copper, 1/4" I.D., 1/6" Pitch

FIGURE 3 – 45-MHz TEST CIRCUIT SCHEMATIC



L1 14 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core
L2 10 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core

6

TYPICAL CHARACTERISTICS

FIGURE 4 – DRAIN CURRENT versus DRAIN to SOURCE VOLTAGE

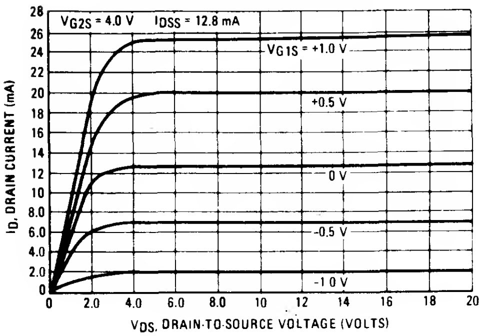


FIGURE 5 – DRAIN CURRENT versus GATE-ONE to SOURCE VOLTAGE

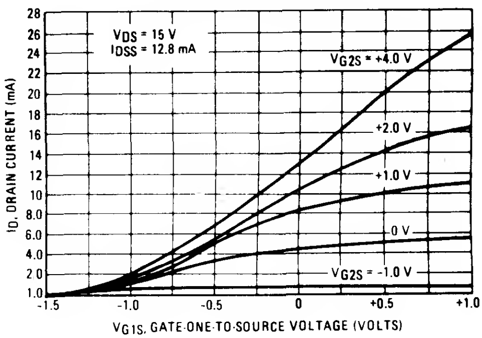


FIGURE 6 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

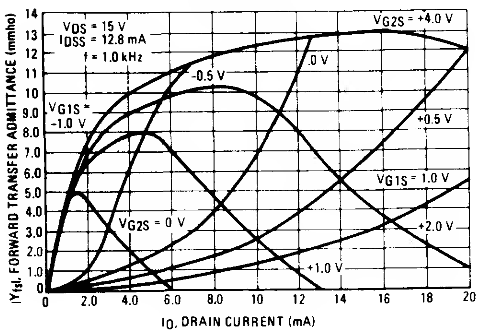


FIGURE 7 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-ONE to SOURCE VOLTAGE

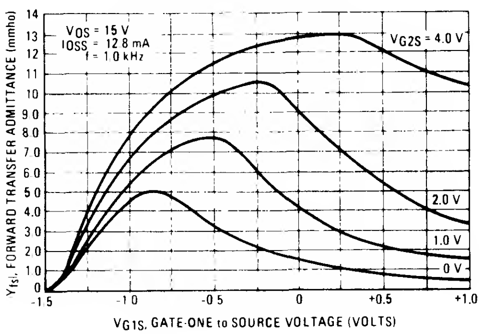


FIGURE 8 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-TWO to SOURCE VOLTAGE

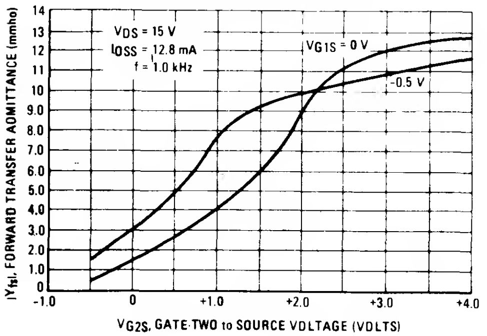


FIGURE 9 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE INPUT AND OUTPUT CAPACITANCE versus GATE-TWO-to-SOURCE VOLTAGE

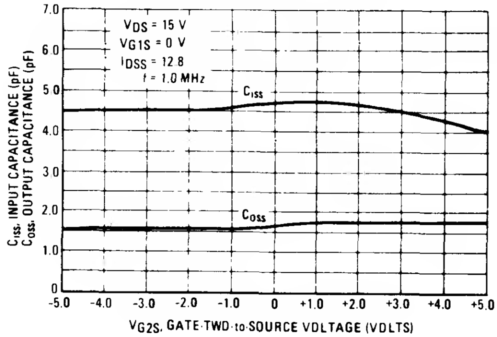


FIGURE 10 – COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus DRAIN CURRENT

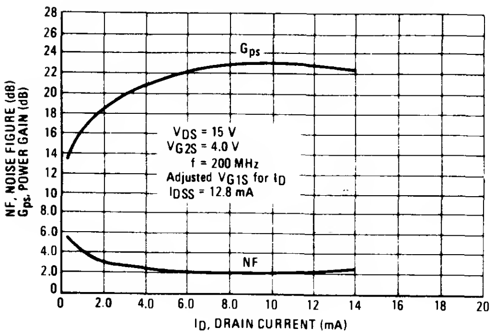


FIGURE 11 — COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus GAIN CONTROL GATE-SUPPLY VOLTAGE — MPF201

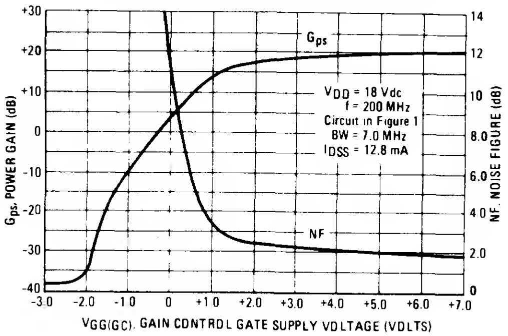


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FIGURE 12 — SMALL-SIGNAL COMMON SOURCE INSERTION POWER GAIN versus GAIN CONTROL GATE-SUPPLY VOLTAGE — MPF203

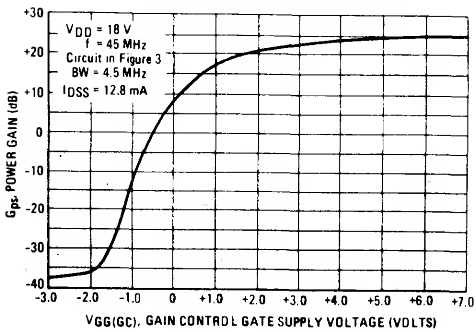


FIGURE 13 — SMALL-SIGNAL COMMON-SOURCE CONVERSION POWER GAIN versus LOCAL OSCILLATOR INPUT VOLTAGE — MPF202

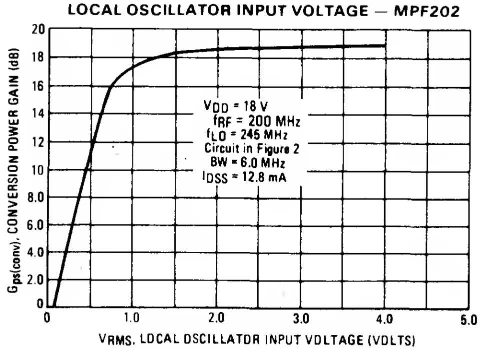


FIGURE 14 — SMALL-SIGNAL GATE ONE FORWARD TRANSFER ADMITTANCE versus FREQUENCY

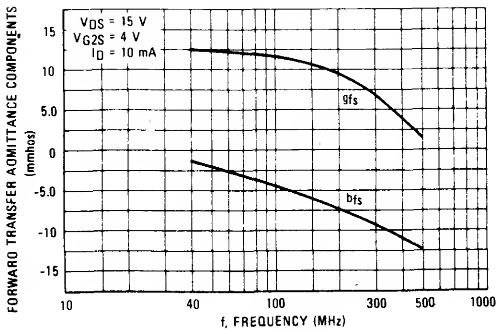


FIGURE 15 — SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

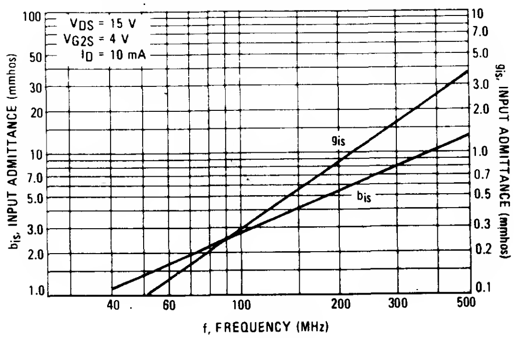


FIGURE 16 — SMALL-SIGNAL GATE ONE OUTPUT ADMITTANCE versus FREQUENCY

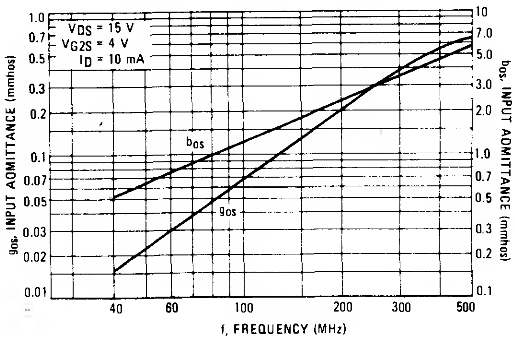
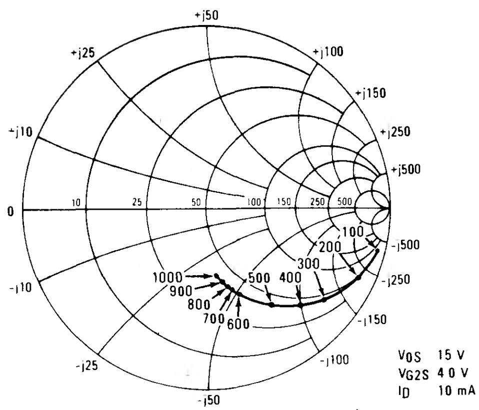
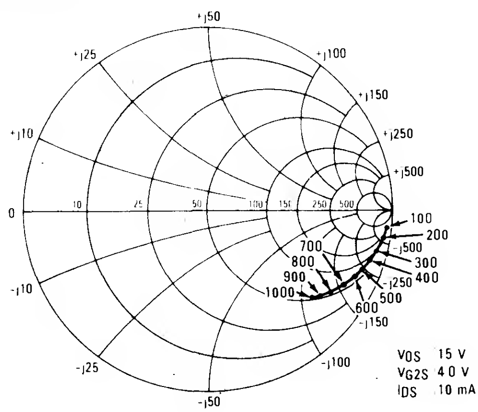


FIGURE 17 — S PARAMETERS PLOTTED ON 50 OHM SMITH CHART



S_{11}



S_{22}

MPF211
MPF212
MPF213

CASE 317-01, STYLE 1

DUAL-GATE MOSFET VHF AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	MPF211 MPF212	MPF213	Unit
Drain-Source Voltage	V_{DS}	27	35	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	35 35	40 40	Vdc
Drain Current — Continuous	I_D	50		mAdc
Gate Current	I_{G1} I_{G2}	±10 ±10		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 8.0		Watt mW/°C
Lead Temperature, 1/16″ From Seated Surface for 10 Seconds	T_L	260		°C
Junction Temperature Range	T_J	−65 to +150		°C
Storage Channel Temperature Range	T_{stg}	−65 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{G1S} = V_{G2S} = −4.0 Vdc, I_D = 10 μAdc)	 MPF211,212 MPF213	$V_{(BR)DSX}$	 25 30	 — —	Vdc
Instantaneous Drain-Source Breakdown Voltage(1) (V_{G1S} = V_{G2S} = −4.0 Vdc, I_D = 10 μAdc)	 MPF211,212 MPF213	$V_{(BR)DSX}$	 27 35	 — —	Vdc
Gate 1-Source Breakdown Voltage(2) (V_{G2S} = V_{DS} = 0, I_{G1} = ±10 mAdc)		$V_{(BR)G1SO}$	±6.0	—	Vdc
Gate 2-Source Breakdown Voltage(2) (V_{G1S} = V_{DS} = 0, I_{G2} = ±10 mAdc)		$V_{(BR)G2SO}$	±6.0	—	Vdc
Gate 1 Leakage Current (V_{G1S} = ±5.0 Vdc, V_{G2S} = V_{DS} = 0) (V_{G1S} = −5.0 Vdc, V_{G2S} = V_{DS} = 0, T_A = 150°C)		I_{G1SS}	 ±0.04(Typ) —	 ±100 −100	 nAdc μAdc
Gate 2 Leakage Current (V_{G2S} = ±5.0 Vdc, V_{G1S} = V_{DS} = 0) (V_{G2S} = −5.0 Vdc, V_{G1S} = V_{DS} = 0, T_A = 150°C)		I_{G2SS}	 ±0.04(Typ) —	 ±100 −100	 nAdc μAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 2.0 μAdc)	 MPF211,213 MPF212	$V_{G1S(off)}$	 −0.5 −0.5	 −5.5 −4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 20 μAdc)	 MPF211 MPF212,213	$V_{G2S(off)}$	 −0.2 −0.2	 −2.5 −4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(3) (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)		I_{DSS}	6.0	4.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(4) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, V_{G1S} = 0, f = 1.0 kHz)	 MPF211,212 MPF213	$\|Y_{fs}\|$	 17 15	 40 35	mmhos
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{rss}	0.005	0.05	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1) (V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 2)	 MPF211 MPF211,213	NF	 — —	 4.0 4.5	dB

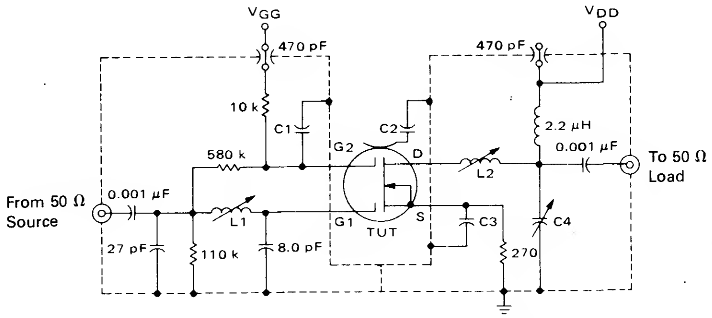
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Common Source Power Gain		G_{ps}			dB
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	MPF211		24	35	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 2)	MPF211		29	37	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 2)	MPF213		27	35	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RE} = 200 MHz) (Figure 3)	MPF212	G_c(6)	21	38	
Bandwidth		BW			MHz
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	MPF211		5.0	12	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RE} = 200 MHz) (Figure 3)	MPF212		4.0	7.0	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 2)	MPF211,213		3.5	6.0	
Gain Control Gate-Supply Voltage(5)		$V_{GG(GC)}$			Vdc
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 200 MHz) (Figure 1)	MPF211		—	−2.0	
(V_{DD} = 24 Vdc, ΔG_{ps} = −30 dB, f = 45 MHz) (Figure 2)	MPF211,213		—	±1.0	

(1) Measured after five seconds of applied voltage.
(2) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate voltage limiting network is functioning properly.
(3) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
(4) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating. The signal is applied to Gate 1 with Gate 2 at ac ground.
(5) ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7.0 Volts (MPF211) and V_{GG} = 6.0 Volts (MPF213).
(6) Power Gain Conversion. Amplitude at input from local oscillator is adjusted for maximum G_c.

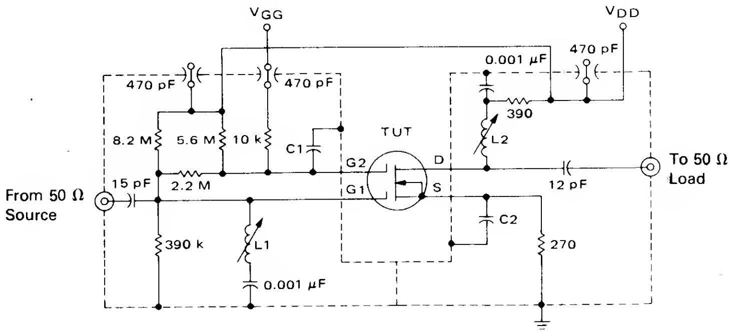
6

FIGURE 1 — 200 MHz POWER GAIN, GAIN CONTROL VOLTAGE, AND NOISE FIGURE TEST CIRCUIT



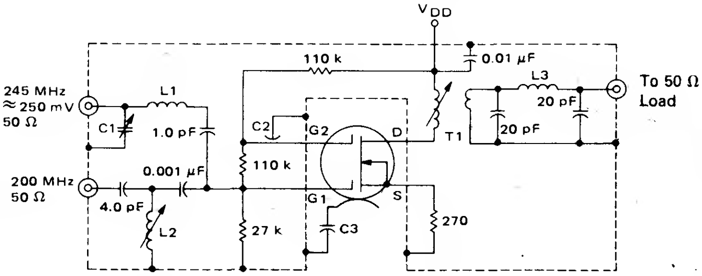
C1, C2 & C3: Leadless disc ceramic, 0.001 μF
C4: Arco 462, 5-80 pF, or equivalent
L1: 3 Turns #18, 3/16″ diameter aluminum slug
L2: 8 Turns #20, 3/16″ diameter aluminum slug

FIGURE 2 — 45-MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C1: Leadless disc ceramic, 0.001 μF
C2: Leadless disc ceramic, 0.01 μF
L1: 8 Turns #28, 5/32″ diameter form, type "J" slug
L2: 9 Turns #28, 5/32″ diameter form, type "J" slug

FIGURE 3 — 200-MHz-to-45-MHz CIRCUIT FOR CONVERSION POWER GAIN



L1: 7 Turns #34, 1/4" diameter aluminum slug
L2: 5-1/2 Turns #20, 1/4" diameter aluminum slug
L3: 7 Turns #24, 1/4" diameter air core

C1: Arco type 462, 5-80 pF
C2: 0.001 μF leadless disc
C3: 0.01 μF leadless disc

T1: Pri: 25 Turns #30, close wound on 1/4" diameter form, type "J" slug
Sec: 4 Turns #30, centered over primary

TYPICAL CHARACTERISTICS

FIGURE 4 — DRAIN CURRENT versus DRAIN-TO-SOURCE VOLTAGE

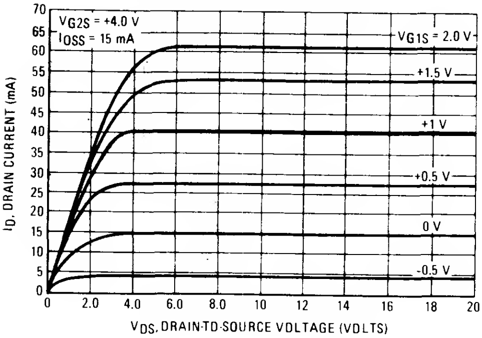
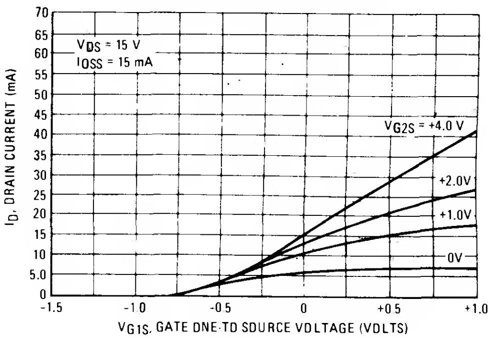


FIGURE 5 — DRAIN CURRENT versus GATE ONE-TO-SOURCE VOLTAGE



SMALL-SIGNAL COMMON-SOURCE PARAMETER — GATE ONE

FIGURE 6 — FORWARD TRANSFER ADMITTANCE versus GATE TWO-TO-SOURCE VOLTAGE

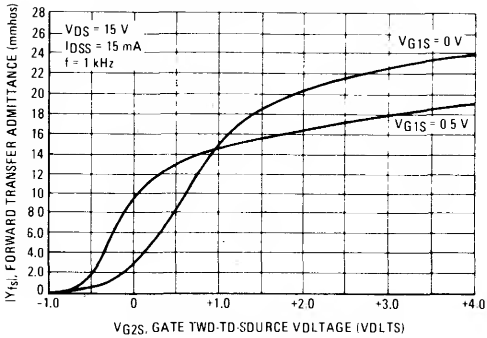


FIGURE 7 — FORWARD TRANSFER ADMITTANCE versus GATE ONE-TO-SOURCE VOLTAGE

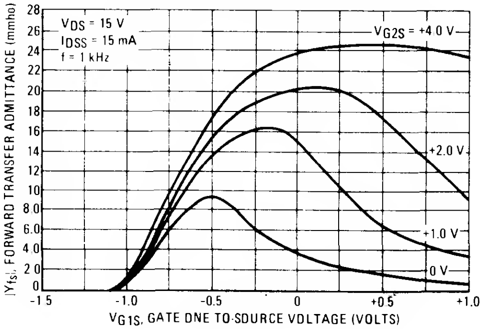


FIGURE 8 — FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

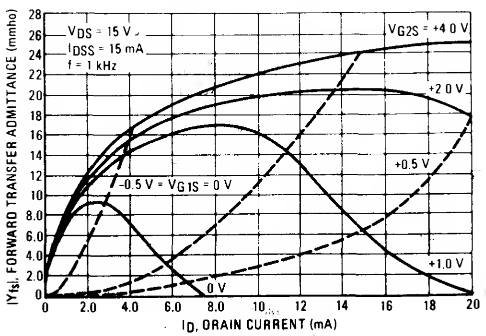


FIGURE 9 — INPUT AND OUTPUT CAPACITANCE versus GATE TWO-TO-SOURCE VOLTAGE

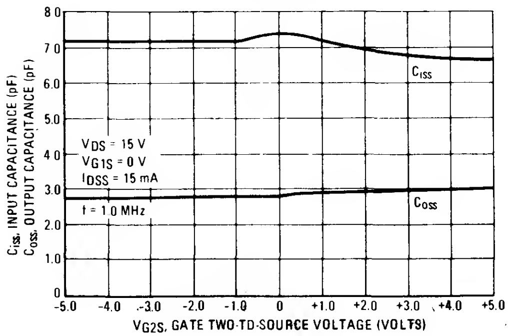


FIGURE 10 — SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

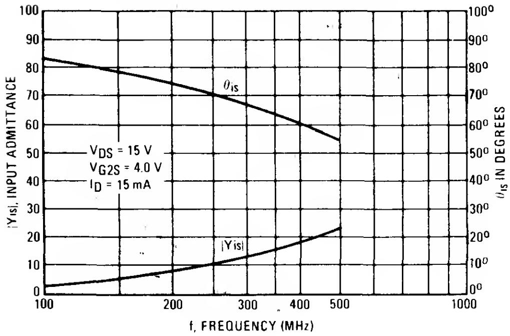


FIGURE 11 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus FREQUENCY

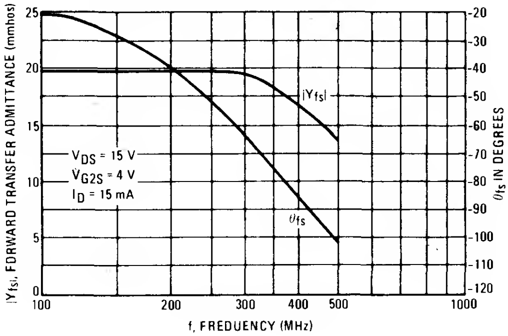


FIGURE 12 — SMALL-SIGNAL GATE ONE REVERSE TRANSFERS ADMITTANCE versus FREQUENCY

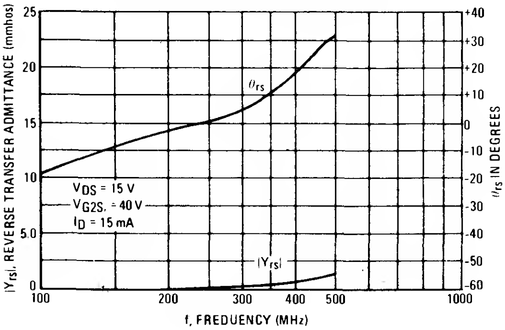


FIGURE 13 — SMALL-SIGNAL GATE ONE OUTPUT ADMITTANCE versus FREQUENCY

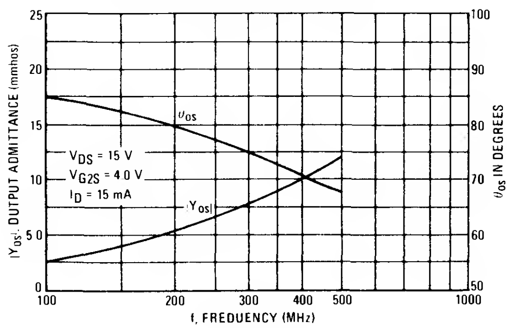


FIGURE 14 — RELATIVE SMALL-SIGNAL POWER GAIN versus GAIN CONTROL GATE SUPPLY VOLTAGE MPF211

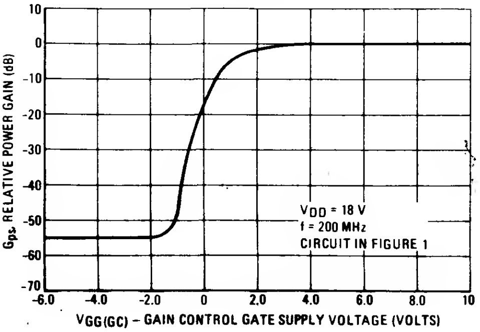


FIGURE 15 — COMMON SOURCE SPOT NOISE FIGURE versus GAIN CONTROL GATE SUPPLY VOLTAGE MPF211

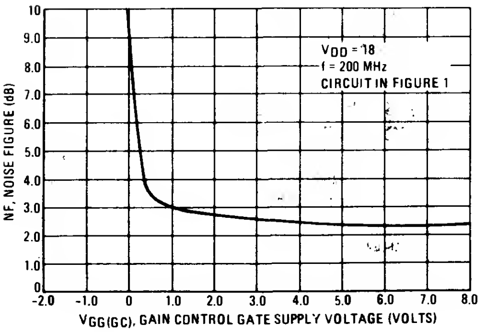


FIGURE 16 — SMALL-SIGNAL COMMON-SOURCE INSERTION POWER GAIN versus GAIN CONTROL GATE SUPPLY VOLTAGE MPF211, 213

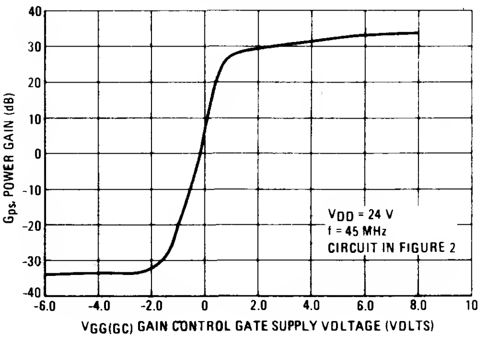


FIGURE 17 — OPTIMUM SPOT NOISE FIGURE versus FREQUENCY

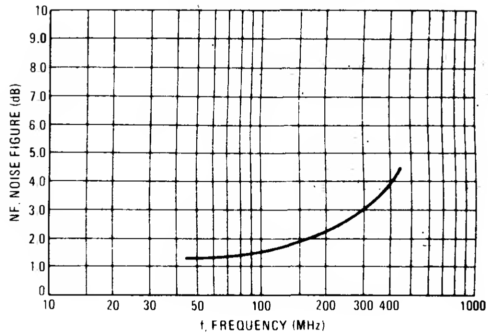
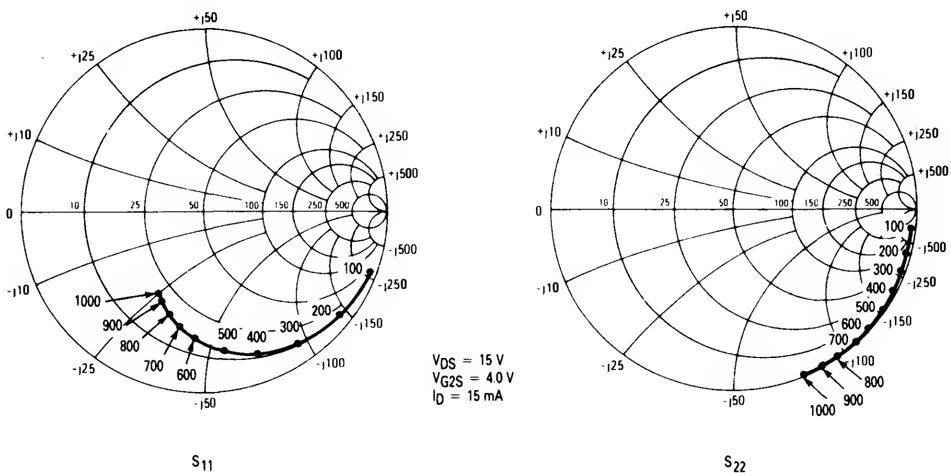


FIGURE 18 — INPUT/OUTPUT IMPEDANCE



MPF256

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	5.0	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 200 μAdc)		$V_{GS(off)}$	0.5	—	7.5	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	 Red Green Violet	I_{DSS}*	 3.0 6.0 11	 — — —	 7.0 13 18	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{fs}\|$	6.0	—	—	mmhos
Input Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{iss}	—	3.0	—	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{rss}	—	1.2	—	pF
Output Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 kHz)		C_{oss}	—	2.0	—	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 15 Vdc, R_S = 50 Ohms)	 100 MHz 400 MHz	NF	 — —	 — —	 2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 Vdc, R_S = 50 Ohms)	 100 MHz 400 MHz	G_{ps}	 20 12	 — —	 — —	dB

*To characterize these devices to narrower limits, the entire production lot is tested and divided into color-coded groups, with each color dot representing an I_{DSS} range.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

MPF521

CASE 317-01, STYLE 1

MOSFET
DUAL GATE
VHF AMPLIFIER TRANSISTOR

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30	Vdc
Drain Current	I_D	30	mAdc
Gate Current	I_{G1F} I_{G2F}	10 10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating Channel Temperature	$T_{channel}$	150	°C
Lead Temperature, 1/16" From Seated Surface for 10 Seconds	T_L	200	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

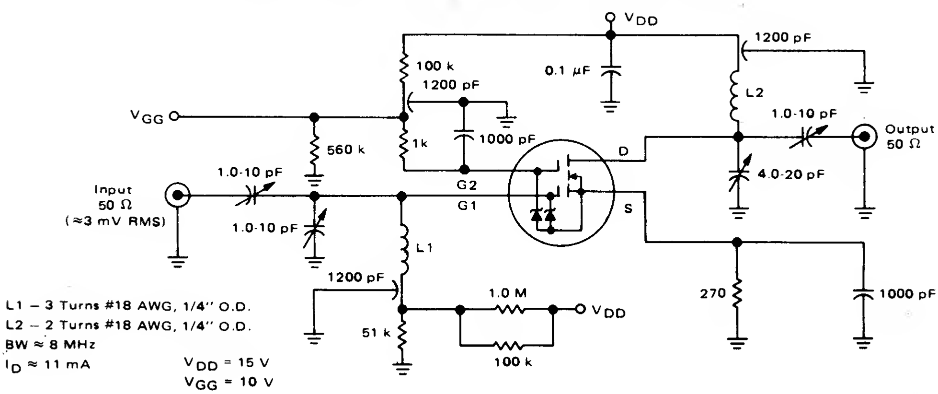
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate 1-Source Breakdown Voltage (V_{G2} = V_{DS} = 0, I_{G1} = 10 μAdc)	$V_{(BR)G1SO}$	10	15	—	Vdc
Gate 2-Source Breakdown Voltage (V_{G1S} = V_{DS} = 0, I_{G2} = 10 μAdc)	$V_{(BR)G2SO}$	12	16	—	Vdc
Gate 1 Reverse Leakage Current (V_{G1S} = 5.0 Vdc, V_{G2S} = V_{DS} = 0)	I_{G1SS}	—	30	100	nAdc
Gate 2 Reverse Leakage Current (V_{G2S} = 5.0 Vdc, V_{G1S} = V_{DS} = 0)	I_{G2SS}	—	30	100	nAdc
Drain-Source Breakdown Voltage (V_{G2} = 0, I_D = 10 μAdc)	$V_{(BR)DS}$	25	28	—	Vdc
ON CHARACTERSTICS					
Gate-Source Threshold Voltage (V_{G2S} = 10 Vdc, I_D = 10 μAdc, V_{DS} = 15 V) (V_{G1S} = 4.0 Vdc, I_D = 10 μAdc, V_{DS} = 15 V)	$V_{G1S(TH)}$ $V_{G2S(TH)}$	0.5 0.5	1.2 1.0	2.0 2.0	Vdc
Gate-Source On Voltage (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc)	$V_{G1S(on)}$	2.0	2.6	4.0	Vdc
"On" Drain Current (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, V_{G1S} = 3.0 Vdc)	$I_{D(on)}$	5.0	15	20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(1) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 200 MHz)	$\|Y_{fs}\|$ Y_{fs}	10 —	12 10.57-j6.86	20 —	mmhos
Input Admittance(1) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 200 MHz)	Y_{is}	—	0.524 + j4.27	—	mmhos
Reverse Transfer Admittance(1) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 200 MHz)	Y_{rs}	—	-1.7-j9.8	—	μmhos
Output Admittance(1) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 200 MHz)	$\|Y_{os}\|$	—	0.126 + j1.79	—	mmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, V_{G1} = 2.5 Vdc, f = 1.0 MHz)	C_{iss}	—	3.3	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, V_{G1} = 2.5 Vdc, f = 1.0 MHz)	C_{rss}	—	0.015	0.03	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, V_{G1} = 2.5 Vdc, f = 1.0 MHz)	C_{oss}	—	1.1	2.5	pF

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figures 1 and 9) (V_{DS} = 15 Vdc, V_{GG} = 10 V, f = 200 MHz)	NF	—	1.7	3.5	dB
Common Source Power Gain (Figures 1 and 9) (V_{DS} = 15 Vdc, V_{GG} = 10 V, f = 200 MHz, BW = 7.0 MHz (Min))	G_{ps}	21	25	—	dB

(1) All y-parameters are with respect to Gate 1.

FIGURE 1 — 200 MHz NOISE FIGURE AND POWER GAIN TEST CIRCUIT



TYPICAL CHARACTERISTICS

FIGURE 2 — DRAIN CURRENT versus DRAIN to SOURCE VOLTAGE

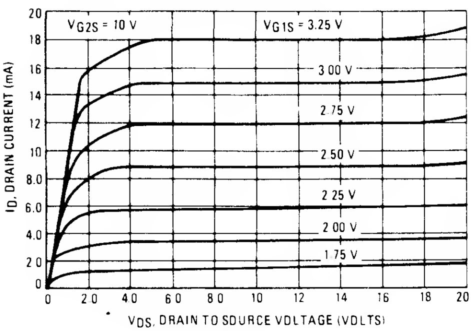


FIGURE 3 — DRAIN CURRENT versus GATE-ONE to SOURCE VOLTAGE

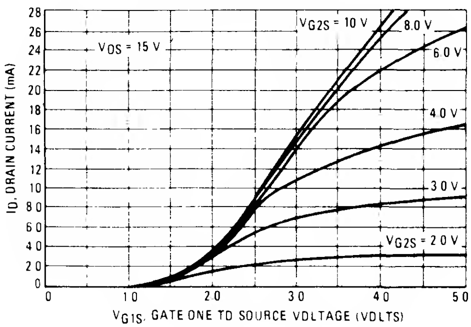


FIGURE 4 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-ONE to SOURCE VOLTAGE

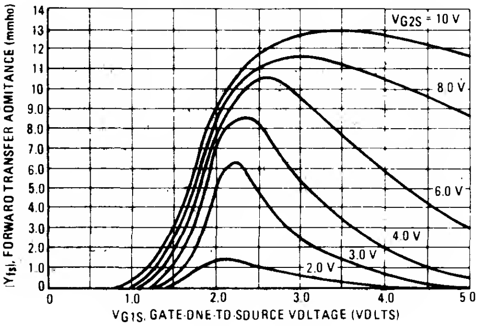


FIGURE 5 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

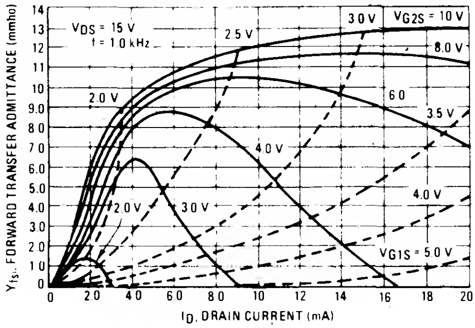


FIGURE 6 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE INPUT AND OUTPUT CAPACITANCE versus GATE-TWO to SOURCE VOLTAGE

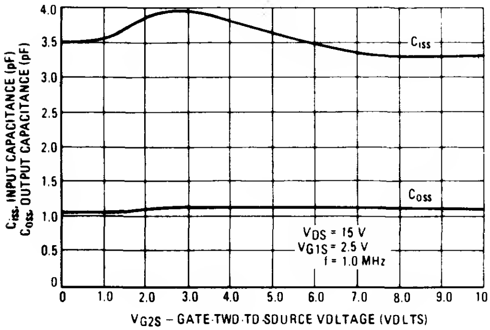


FIGURE 7 – COMMON SOURCE POWER GAIN versus DRAIN SUPPLY CURRENT

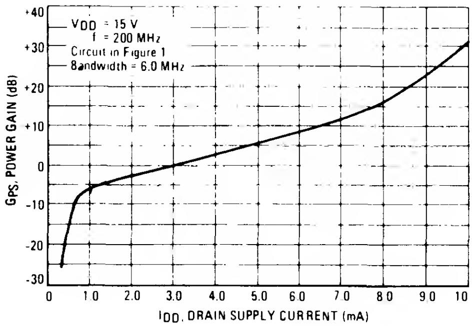


FIGURE 8 – COMMON SOURCE POWER GAIN AND SPOT NOISE FIGURE versus DRAIN CURRENT

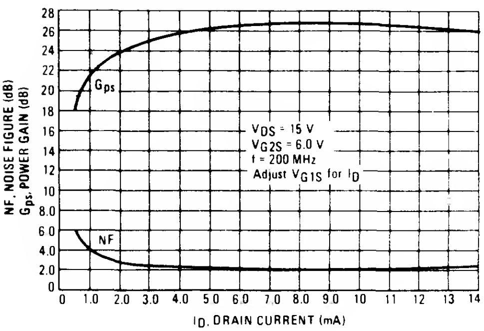


FIGURE 9 – COMMON SOURCE POWER GAIN AND SPOT NOISE FIGURE versus GAIN CONTROL GATE-SUPPLY VOLTAGE

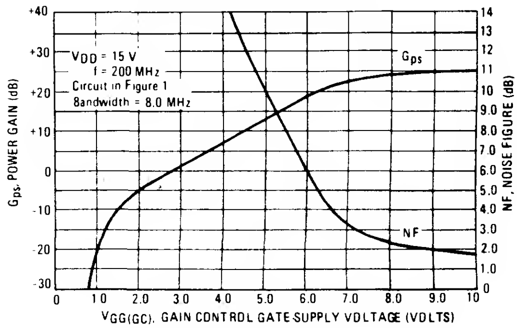


FIGURE 10 — SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

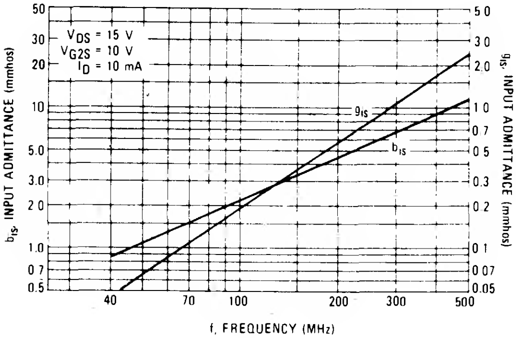


FIGURE 11 — SMALL-SIGNAL COMMON SOURCE GATE ONE FORWARD TRANSFER ADMITTANCE versus FREQUENCY

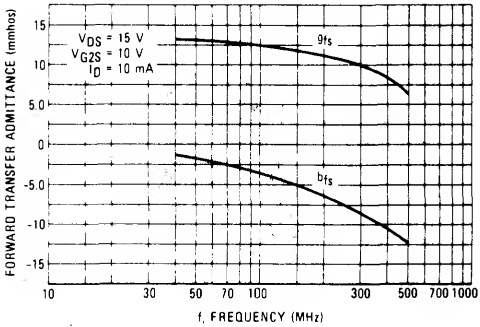


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FIGURE 12 — SMALL-SIGNAL COMMON SOURCE OUTPUT ADMITTANCE versus FREQUENCY

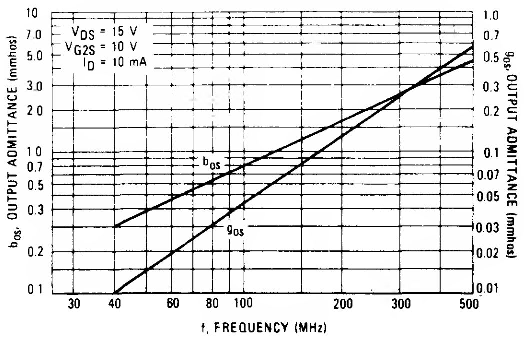
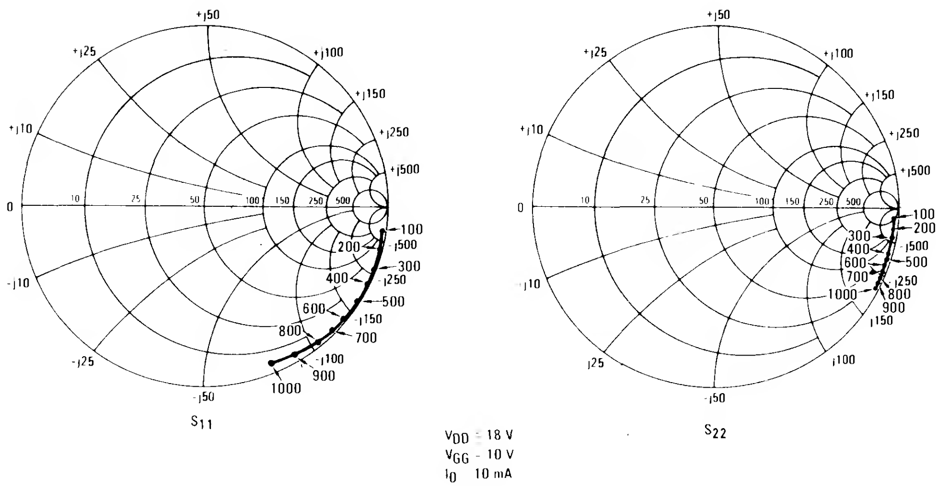


FIGURE 13 — INPUT/OUTPUT IMPEDANCE



MPF820

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
RF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	—	5.0	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 200 μAdc)	$V_{GS(off)}$	—	—	5.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	10	—	—	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}\|$	—	20	—	mmhos
Input Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{iss}	—	15	—	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{rss}	—	3.5	—	pF
Common-Gate Input Conductance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 100 MHz)	g_{ig}	—	16	—	mmhos
Common-Gate Output Conductance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 100 MHz)	G_{og}	—	—	16	μmhos
Common-Gate Forward Transadmittance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 100 MHz)	y_{fg}	—	18	—	mmhos
Common-Gate Reverse Transadmittance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 100 MHz)	y_{rg}	—	—	130	μmhos
Output Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	C_{oss}	—	3.5	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, I_D = 10 mAdc, See Figure 5)	NF	—	—	4.0	dB
Small-Signal Power Gain (V_{DS} = 15 Vdc, I_D = 10 mAdc, See Figure 5)	G_{pg}	—	11	—	dB

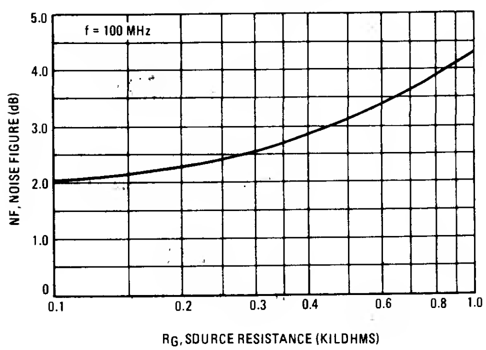


FIGURE 1 — NOISE FIGURE

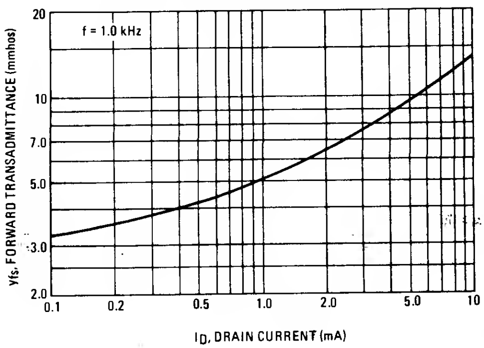


FIGURE 2 — FORWARD TRANSADMITTANCE

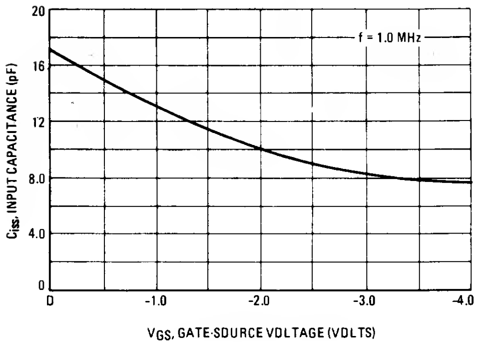


FIGURE 3 — INPUT CAPACITANCE

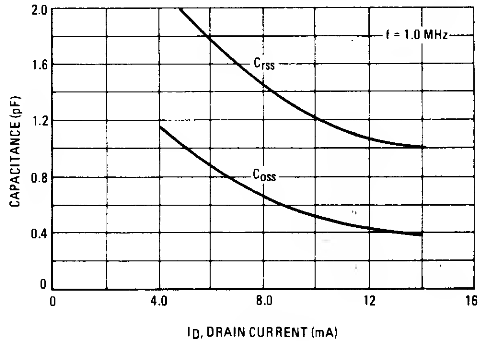
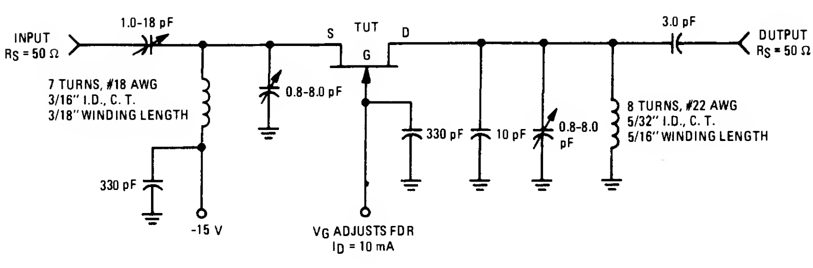


FIGURE 4 — OUTPUT AND REVERSE TRANSFER CAPACITANCE

FIGURE 5 — 100 MHz TEST CIRCUIT



MPF930
MPF960
MPF990

CASE 29-03, STYLE 22
TO-226AE

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to MFE930 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPF930	MPF960	MPF990	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}		±30		Vdc
Drain Current Continuous (1) Pulsed (2)	 I_D I_{DM}		 2.0 3.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		 1.0 8.0		 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to 150		°C
Thermal Resistance	θ_{JA}		125		°C/W

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	 MPF930 MPF960 MPF990	$V_{(BR)DSX}$	 35 60 90	 — — —	 — — —	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})		$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 0.5 A)	 MPF930 MPF960 MPF990	$V_{DS(on)}$	 — — —	 0.4 0.6 0.6	 0.7 0.8 1.0	Vdc
(I_D = 1.0 A)	MPF930 MPF960 MPF990		— — —	0.9 1.2 1.2	1.4 1.7 2.0	
(I_D = 2.0 A)	MPF930 MPF960 MPF990		— — —	2.2 2.8 2.8	3.0 3.5 4.0	
Static Drain-Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	 MPF930 MPF960 MPF990	$r_{DS(on)}$	 — — —	 0.9 1.2 1.2	 1.4 1.7 2.0	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	60	70	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	13	18	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	49	60	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{fs}	200	380	—	mmhos
SWITCHING CHARACTERISTICS						
Turn-On Time		t_{on}	—	7.0	15	ns
Turn-Off Time		t_{off}	—	7.0	15	ns

*Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

6

MPF970
MPF971

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C
Operating Temperature Range	$T_{channel}$	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 — —	 1.0 1.0	 nAdc μAdc
Drain-Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 150°C) (V_{DS} = 15 Vdc, V_{GS} = 7.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 7.0 Vdc, T_A = 150°C)	 MPF970 MPF970 MPF971 MPF971	$I_{D(off)}$	 — — — —	 — — — —	 10 10 10 10	 nAdc μAdc nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 MPF970 MPF971	$V_{GS(off)}$	 5.0 1.0	 — —	 12 7.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	 MPF970 MPF971	I_{DSS}	 15 2.0	 — —	 100 50	mAdc
Drain-Source On-Voltage (I_D = 10 mAdc, V_{GS} = 0) (I_D = 1.5 mAdc, V_{GS} = 0)		$V_{DS(on)}$	 — —	 — —	 1.5 1.5	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 MPF970 MPF971	$r_{DS(on)}$	 — —	 — —	 100 250	Ohms
SMALL-SIGNAL CHARACTERISTICS						
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 MPF970 MPF971	$r_{ds(on)}$	 — —	 — —	 100 250	Ohms
Input Capacitance (V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz) (V_{GS} = 7.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	 MPF970 MPF971	C_{iss}	 — —	 — —	 12 12	pF
Reverse Transfer Capacitance (V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz) (V_{GS} = 7.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	 MPF970 MPF971	C_{rss}	 — —	 — —	 5.0 5.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS (See Figure 6, R_K = 0) (1)						
Rise Time		t_r				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	2.0	5.0	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	3.0	5.0	
Fall Time		t_f				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	9.0	15	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	68	80	
Turn-On Time		t_{on}				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	3.5	8.0	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	5.0	10	
Turn-Off Time		t_{off}				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	13	25	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	88	120	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

6

FIGURE 1 – EFFECT OF I_{DSS} ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE

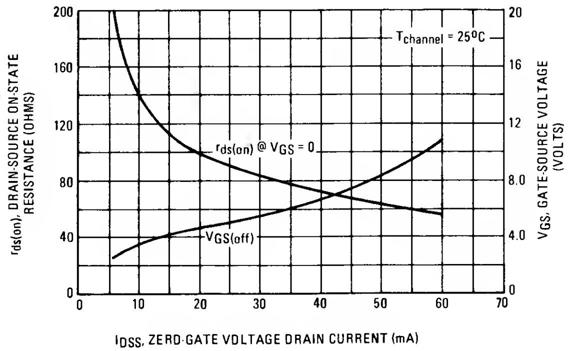


FIGURE 2 – TURN-ON DELAY TIME

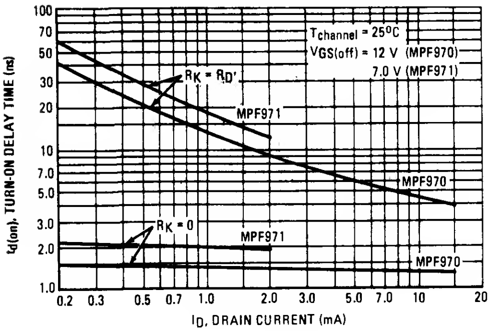


FIGURE 3 – RISE TIME

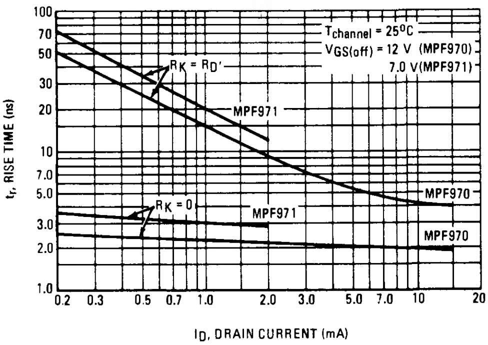


FIGURE 4 – TURN-OFF DELAY TIME

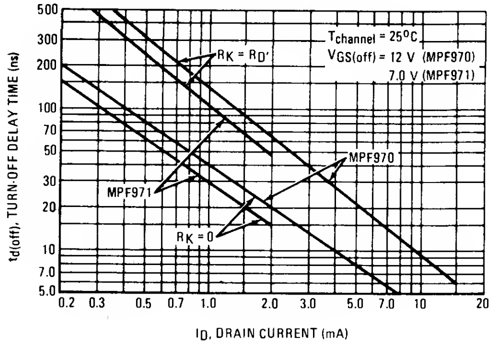


FIGURE 5 – FALL TIME

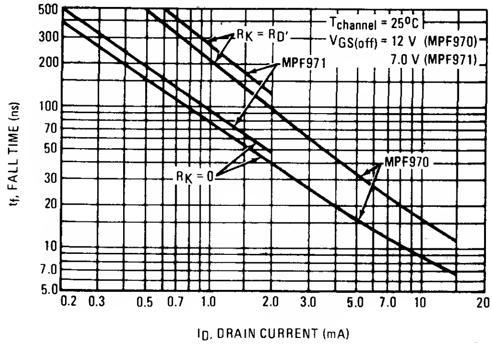
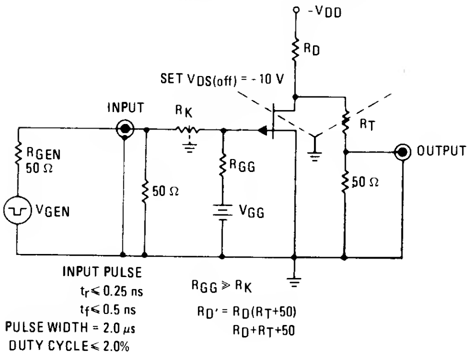


FIGURE 6 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 6. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($+V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{Gen} and R_K. C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds}, turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to R_D, which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) R_K = 0 (low impedance) the driving source impedance is that of the generator.

FIGURE 7 – TYPICAL FORWARD TRANSFER ADMITTANCE

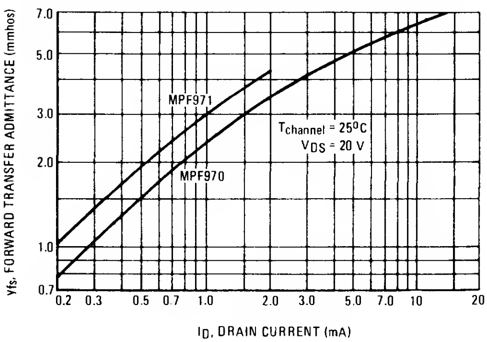


FIGURE 8 – TYPICAL CAPACITANCE

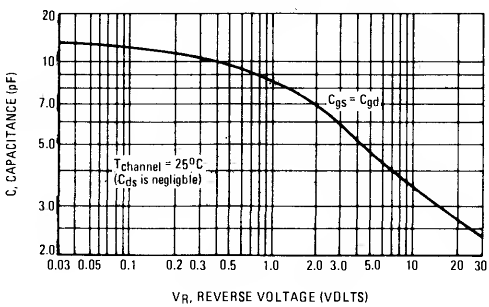


FIGURE 9 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

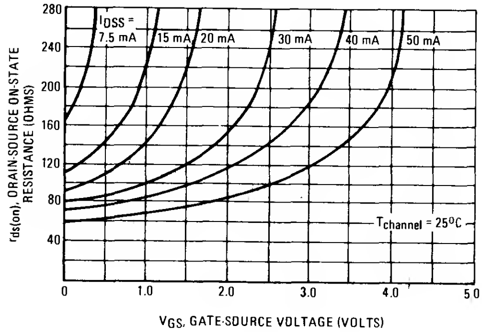


FIGURE 10 – EFFECT OF TEMPERATURE ON DRAIN-SOURCE ON-STATE RESISTANCE

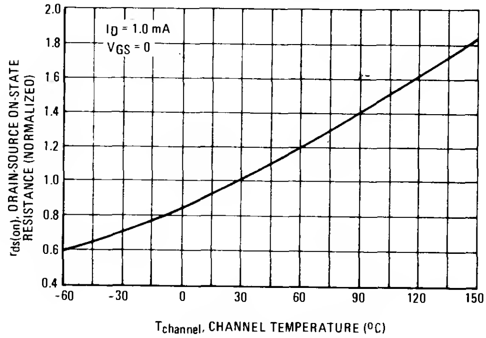
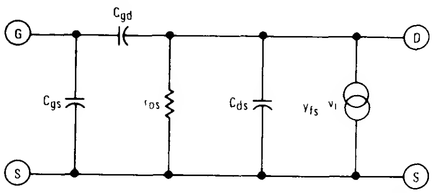


FIGURE 11 – LOW FREQUENCY CIRCUIT MODEL



$y_{is} = j\omega C_{iss}$
$y_{os} = 1\ r_{oss} + j\omega C_{oss}$
$y_{fs} = y_{fs}$
$y_{rs} = -j\omega C_{rss}$

$C_{iss} = C_{gd} + C_{gs}$
$C_{rss} = C_{gd}$
$C_{oss} = C_{gd} + C_{ds},\ C_{ds} \approx 0$

MPF1010

CASE 29-03, STYLE 22
TO-92 (TO-226AE)

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	100	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current — Continuous(1) Pulsed(2)	I_D I_{DM}	500 1000	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1 8	Watts mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to +150	°C
Thermal Resistance Junction to Ambient	θ_{JA}	125	°C/W

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	100	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 60 V, V_{GS} = 0)	I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current (V_{GS} = 10 Vdc, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (I_D = 15 mA, V_{DS} = V_{GS})	$V_{GS(th)}$	0.3	—	2.5	Vdc
Drain-Source On-Voltage (I_D = 120 mA, V_{GS} = 5 V) (I_D = 20 mA, V_{GS} = 3.5 V)	$V_{DS(on)}$	— —	— —	1.2 0.16	Vdc
On State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V) (V_{DS} = 25 V, V_{GS} = 5 V)	$I_{D(on)}$	500 250	700	—	mA
Forward Transconductance (V_{DS} = 15 V, I_D = 0.5 A)	g_{fs}	100	300	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	60	70	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	49	60	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	13	18	pF
SWITCHING CHARACTERISTICS*					
Turn-On Time See Figure 1	t_{on}	—	7	15	ns
Turn-Off Time See Figure 1	t_{off}	—	7	15	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

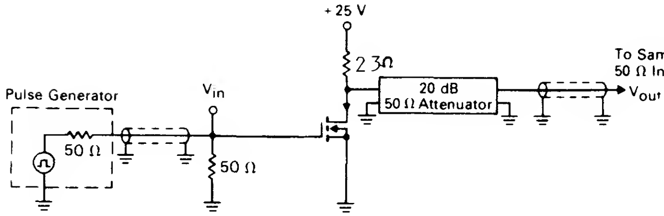
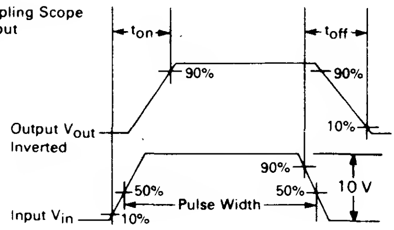


FIGURE 2 — SWITCHING WAVEFORMS



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MPF4093

CASE 29-03, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Gate-Source Voltage	V_{GS}	−40	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 3.0	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current (V_{DG} = −20 V, I_S = 0)	I_{DGO}	—	1.0	nA
Drain-Gate Leakage (V_{DG} = −20 V, I_S = 0, T_A = 150°C)	I_{DGO}	—	400	nA
Drain Cutoff Current (V_{DS} = 20 V, V_{GS} = −6.0 V)	$I_{D(off)}$	—	1.0	nA
Drain-Gate "OFF" Current (V_{DS} = 20 V, V_{GS} = −6.0 V, T_A = 150°C)	$I_{D(off)}$	—	400	nA
Gate 1 to Source Cutoff Voltage (V_{DS} = 20 V, I_D = 1.0 nA)	$V_{G1S(off)}$	−1.0	−5.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 20 V, V_{GS} = 0)	I_{DSS}	8.0	—	mA
Drain-Source On-Voltage (V_{GS} = 0, I_D = 2.5 mA)	$V_{DS(on)}$	—	0.2	Vdc
Static Drain-Source On Resistance (V_{GS} = 0, I_D = 1.0 mA) (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{DS(on)}$	 — —	 80 80	Ω
SMALL-SIGNAL CHARACTERISTICS				
Input Capacitance (V_{DS} = 20 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	16	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −20 V, f = 1.0 MHz)	C_{rss}	—	5.0	pF
SWITCHING CHARACTERISTICS				
Delay Time	t_d	—	20	ns
Rise Time	t_r	—	40	ns
Turn-Off Time	t_{off}	—	80	ns

MPF4117,A
MPF4118,A
MPF4119,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
DC AMPLIFIER TRANSISTOR

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−40	Vdc
Drain-Gate Voltage	V_{DG}	−40	Vdc
Gate Current	I_G	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +125	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (V_{DS} = 0, I_G = −1.0 μAdc)		$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)	MPF4117, 4118, 4119 MPF4117A, 4118A, 4119A	I_{GSS}	— —	−10 −1.0	pAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 125°C)	MPF4117, 4118, 4119 MPF4117A, 4118A, 4119A		— —	−25 −2.5	nAdc
Gate Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 nAdc)	MPF4117,A MPF4118,A MPF4119,A	$V_{GS(off)}$	−0.6 −1.0 −2.0	−1.8 −3.0 −6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 10 Vdc, V_{GS} = 0)	MPF4117,A MPF4118,A MPF4119,A	I_{DSS}	0.03 0.08 0.20	0.09 0.24 0.60	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	3.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.5	pF
Common-Source Forward Transconductance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	MPF4117,A MPF4118,A MPF4119,A	g_{fs}	70 80 100	210 250 330	μmhos
Common-Source Output Conductance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	MPF4117,A MPF4118,A MPF4119,A	g_{os}	— — —	3.0 5.0 10	μmhos

(1) I_{DSS} is measured during a 2.0 ms interval 100 ms after power is applied.

FIGURE 1 — TRANSFER CHARACTERISTICS

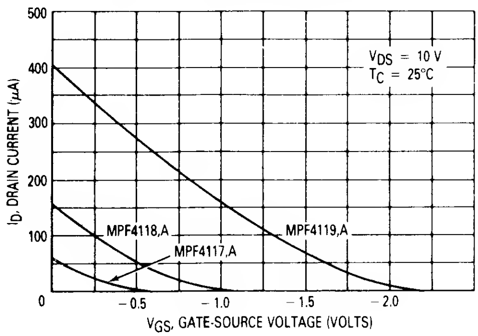


FIGURE 2 — TRANSCONDUCTANCE CHARACTERISTICS

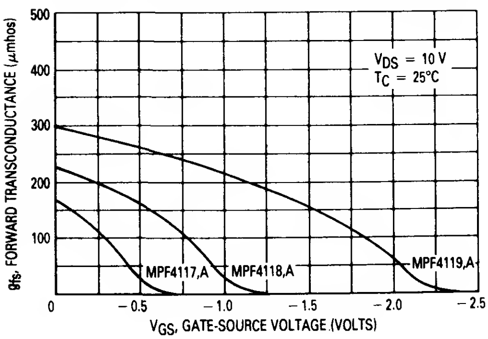
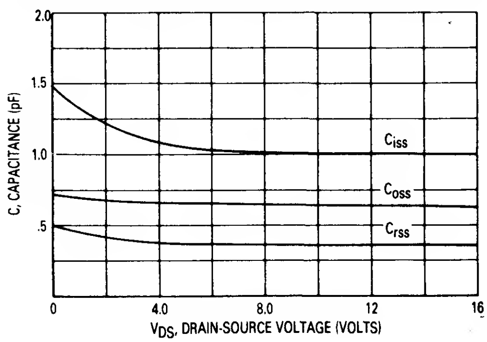


FIGURE 3 — CAPACITANCE versus DRAIN-SOURCE VOLTAGE



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MPF4220,A
MPF4221,A
MPF4222,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
LOW-FREQUENCY

N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -10\ \mu A$, $V_{DS} = 0$ V)		$V_{(BR)GSS}$	−30	—	Vdc
Gate Reverse Current ($V_{GS} = -15$ V, $V_{DS} = 0$ V)		I_{GSS}	—	−100	pA
Gate Source Cutoff Voltage ($V_{DS} = 15$ V, $I_D = 0.1$ nA)	MPF4220,A MPF4221,A MPF4222,A	$V_{GS(off)}$	— — —	−4.0 −6.0 −8.0	Vdc
Gate Source Voltage ($V_{DS} = 15$ V, $I_D = 50\ \mu A$) ($V_{DS} = 15$ V, $I_D = 200\ \mu A$) ($V_{DS} = 15$ V, $I_D = 500\ \mu A$)	MPF4220,A MPF4221,A MPF4222,A	V_{GS}	−0.5 −1.0 −2.0	−2.5 −5.0 −6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 15$ Volts, $V_{GS} = 0$ V)	MPF4220,A MPF4221,A MPF4222,A	I_{DSS}*	+0.5 +2.0 +5.0	+3.0 +6.0 +15.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15$ V, f = 1.0 kHz, $V_{GS} = 0$ V)	MPF4220,A MPF4221,A MPF4222,A	$\|y_{fs}\|$*	1000 2000 2500	4000 5000 6000	μmhos
Output Admittance ($V_{DS} = 15$ V, f = 1.0 kHz, $V_{GS} = 0$ V)	MPF4220,A MPF4221,A MPF4222,A	$\|y_{os}\|$	— — —	10 20 40	μmhos
Input Capacitance ($V_{DS} = 15$ V, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ V, f = 1.0 MHz)		C_{rss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 15$ V, f = 100 Hz, $R_G = 1.0$ MΩ)	MPF4220,A MPF4221,A MPF4222,A	NF	—	2.5	dB

*Pulse Width ≤ 100 msec, Duty Cycle ≤ 10%.

6

MPF4391
MPF4392
MPF4393

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 1.0 0.2	 nAdc μAdc
Drain-Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 100°C)		$I_{D(off)}$	 — —	 — —	 1.0 0.1	 nAdc μAdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 MPF4391 MPF4392 MPF4393	V_{GS}	 4.0 2.0 0.5	 — — —	 10 5.0 3.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 MPF4391 MPF4392 MPF4393	I_{DSS}	 60 25 5.0	 — — —	 130 75 30	mAdc
Drain-Source On-Voltage (I_D = 12 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 3.0 mAdc, V_{GS} = 0)	 MPF4391 MPF4392 MPF4393	$V_{DS(on)}$	 — — —	 — — —	 0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 MPF4391 MPF4392 MPF4393	$r_{DS(on)}$	 — — —	 — — —	 30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, I_D = 60 mAdc, f = 1.0 kHz) (V_{DS} = 15 Vdc, I_D = 25 mAdc, f = 1.0 kHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 kHz)	 MPF4391 MPF4392 MPF4393	$\|y_{fs}\|$	 — — —	 20 17 12	 — — —	mmhos
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 MPF4391 MPF4392 MPF4393	$r_{ds(on)}$	 — — —	 — — —	 30 60 100	Ohms
Input Capacitance (V_{GS} = 15 Vdc, V_{DS} = 0, f = 1.0 MHz)		C_{iss}	—	6.0	10	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Transfer Capacitance		C_{rss}				pF
(V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz)			—	2.5	3.5	
(V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)			—	3.2	—	
SWITCHING CHARACTERISTICS						
Rise Time (See Figure 2)		t_r				ns
($I_{D(on)}$ = 12 mAdc)	MPF4391		—	1.2	5.0	
($I_{D(on)}$ = 6.0 mAdc)	MPF4392		—	2.0	5.0	
($I_{D(on)}$ = 3.0 mAdc)	MPF4393		—	2.5	5.0	
Fall Time (See Figure 4)		t_f				ns
($V_{GS(off)}$ = 12 Vdc)	MPF4391		—	7.0	15	
($V_{GS(off)}$ = 7.0 Vdc)	MPF4392		—	15	20	
($V_{GS(off)}$ = 5.0 Vdc)	MPF4393		—	29	35	
Turn-On Time (See Figures 1 and 2)		t_{on}				ns
($I_{D(on)}$ = 12 mAdc)	MPF4391		—	3.0	15	
($I_{D(on)}$ = 6.0 mAdc)	MPF4392		—	4.0	15	
($I_{D(on)}$ = 3.0 mAdc)	MPF4393		—	6.5	15	
Turn-Off Time (See Figures 3 and 4)		t_{off}				ns
($V_{GS(off)}$ = 12 Vdc)	MPF4391		—	10	20	
($V_{GS(off)}$ = 7.0 Vdc)	MPF4392		—	20	35	
($V_{GS(off)}$ = 5.0 Vdc)	MPF4393		—	37	55	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

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TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 – TURN-ON DELAY TIME

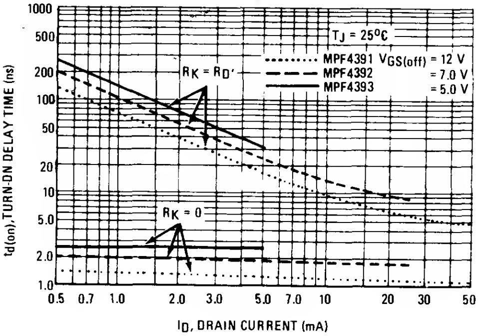


FIGURE 2 – RISE TIME

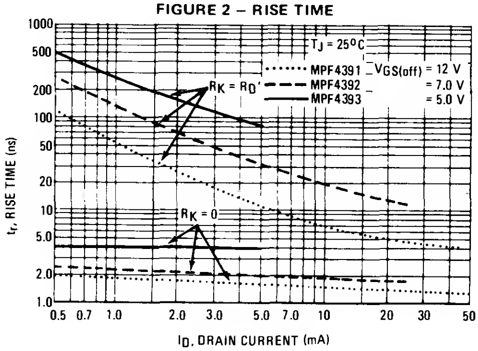


FIGURE 3 – TURN-OFF DELAY TIME

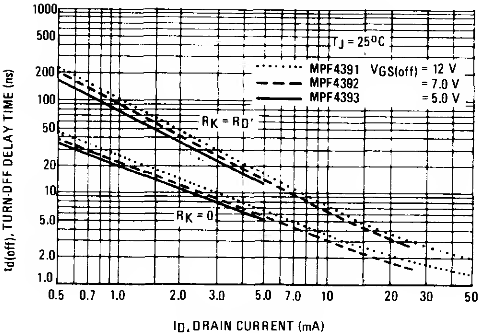


FIGURE 4 – FALL TIME

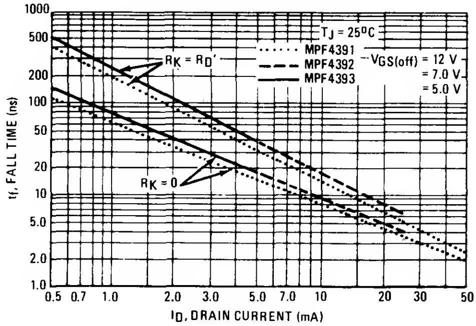
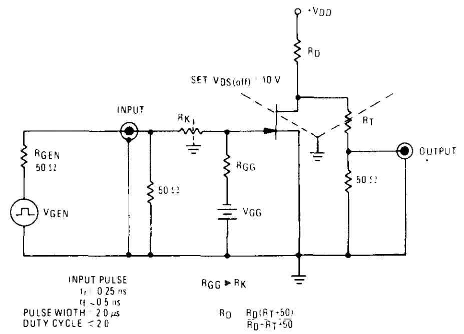


FIGURE 5 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 5. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($-V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{Gen} and R_K. C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds}, turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to R_D' which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) $R_K = 0$ (low impedance) the driving source impedance is that of the generator.

6

FIGURE 6 – TYPICAL FORWARD TRANSFER ADMITTANCE

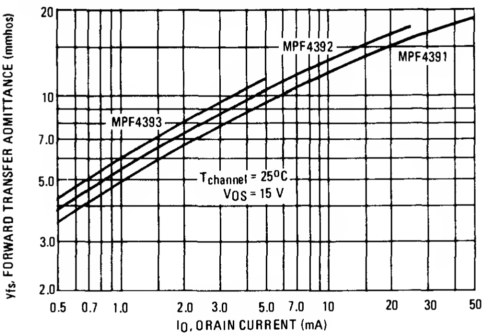


FIGURE 7 – TYPICAL CAPACITANCE

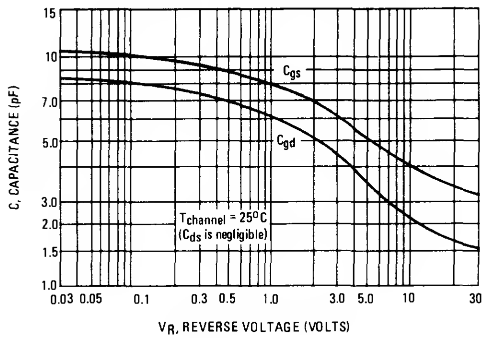


FIGURE 8 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

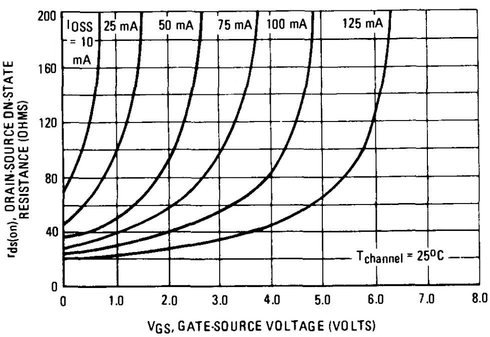


FIGURE 9 – EFFECT OF TEMPERATURE ON DRAIN–SOURCE ON-STATE RESISTANCE

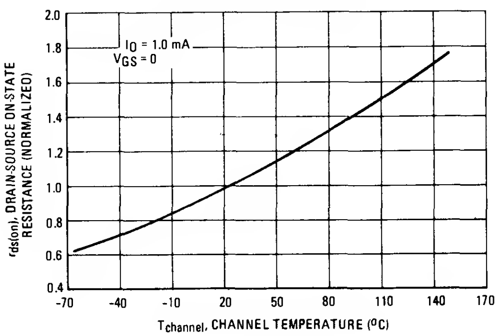
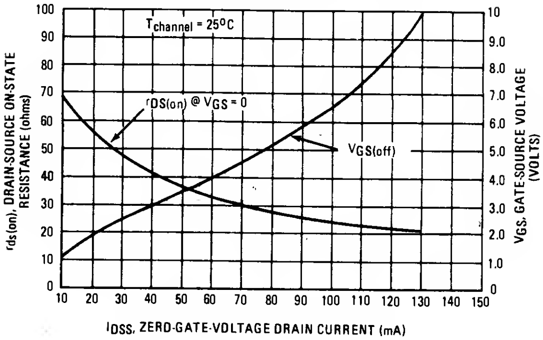


FIGURE 10 – EFFECT OF IDSS ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE



NOTE 2

The Zero-Gate-Voltage Drain Current (I_{DSS}), is the principle determinant of other J-FET characteristics. Figure 10 shows the relationship of Gate-Source Off Voltage ($V_{GS(off)}$) and Drain-Source On Resistance ($r_{ds(on)}$) to I_{DSS}. Most of the devices will be within ±10% of the values shown in Figure 10. This data will be useful in predicting the characteristic variations for a given part number.

For example:

Unknown

$r_{ds(on)}$ and V_{GS} range for an MPF4392

The electrical characteristics table indicates that an MPF4392 has an I_{DSS} range of 25 to 75 mA. Figure 10, shows $r_{ds(on)}$ = 52 Ohms for I_{DSS} = 25 mA and 30 Ohms for I_{DSS} = 75 mA. The corresponding V_{GS} values are 2.2 volts and 4.8 volts.

6

MPF4416,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH-FREQUENCY
AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Gate-Source Voltage MPF4416 MPF4416A	V_{GS}	−30 −35	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Lead Temperature	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −1.0 μA) MPF4416 MPF4416A	$V_{(BR)GSS}$	−30 −35	— —	Vdc
Gate Reverse Current (V_{GS} = −20 V)	I_{GSS}	—	−250	pA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 1.0 nA) MPF4416 MPF4416A	$V_{GS(off)}$	— −2.5	−6.0 −6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 V)	I_{DSS}	5.0	15	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 V, f = 1.0 kHz)	$\|y_{fs}\|$	4500	7500	μmhos
Input Admittance (V_{DS} = 15 V, f = 100 MHz) (V_{DS} = 15 V, f = 400 MHz)	$Re(y_{is})$	— —	100 1000	μmhos
Output Admittance (V_{DS} = 15 V, f = 1.0 kHz)	$\|y_{os}\|$	—	50	μmhos
Output Conductance (V_{DS} = 15 V, f = 100 MHz) (V_{DS} = 15 V, f = 400 MHz)	$Re(y_{os})$	— —	75 100	μmhos
Forward Transconductance* (V_{DS} = 15 V, f = 400 MHz)	$Re(y_{fs})$	4000	—	μmhos
Input Capacitance (V_{DS} = 15 V, f = 1.0 MHz)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, f = 1.0 MHz)	C_{rss}	—	0.8	pF
Output Capacitance (V_{DS} = 15 V, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 V, I_D = 5.0 mA, R_G = 1.0 kΩ, f = 100 MHz) (V_{DS} = 15 V, I_D = 5.0 mA, R_G = 1.0 kΩ, f = 400 MHz)	NF	— —	2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 V, I_D = 5.0 mA, f = 100 MHz) (V_{DS} = 15 V, I_D = 5.0 mA, f = 400 MHz)	G_{ps}	18 10	— —	dB

*Pulse Test Duration = 2.0 msec.

6

MPF4856,A thru MPF4861,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET SWITCHING

N-CHANNEL — DEPLETION

Refer to 2N4856 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	MPF4856,A MPF4857,A MPF4858,A	MPF4859,A MPF4860,A MPF4861,A	Unit
Drain-Source Voltage	V_{DS}	+40	+30	Vdc
Drain-Gate Voltage	V_{DG}	+40	+30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−40	−30	Vdc
Forward Gate Current	I_{GF}	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4		mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	 MPF4856,A, MPF4857,A, MPF4858,A MPF4859,A, MPF4860,A, MPF4861,A	$V_{(BR)GSS}$	 −40 −30	 — —	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 150°C) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 150°C)	 MPF4856,A, MPF4857,A, MPF4858,A MPF4859,A, MPF4860,A, MPF4861,A MPF4856,A, MPF4857,A, MPF4858,A MPF4859,A, MPF4860,A, MPF4861,A	I_{GSS}	 — — — —	 0.25 0.25 0.5 0.5	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	 MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	$V_{GS(off)}$	 −4.0 −2.0 −0.8	 −10 −6.0 −4.0	Vdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −10 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −10 Vdc, T_A = 150°C)		$I_{D(off)}$	 — —	 0.25 0.5	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	I_{DSS}	 50 20 8.0	 — 100 80	mAdc
Drain-Source On-Voltage (I_D = 20 mAdc, V_{GS} = 0) (I_D = 10 mAdc, V_{GS} = 0) (I_D = 5.0 mAdc, V_{GS} = 0)	 MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	$V_{DS(on)}$	 — — —	 0.75 0.5 0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	$r_{ds(on)}$	 — — —	 25 40 60	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz)	 MPF4856 thru MPF4861 MPF4856A thru MPF4861A	C_{iss}	 — —	 18 10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz)	 MPF4856 thru MPF4861 MPF4856A, MPF4859A MPF4857A, MPF4858A, MPF4860A, MPF4861A	C_{rss}	 — — —	 8.0 4.0 3.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Conditions	Device	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	Conditions for MPF4856,A, MPF4859,A:	MPF4856, MPF4859	$t_{d(on)}$	—	6.0	ns
		MPF4856A, MPF4859A		—	5.0	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc,	MPF4857, MPF4860		—	6.0	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc)	MPF4857A, MPF4860A		—	6.0	
		MPF4858, MPF4861		—	10	
		MPF4858A, MPF4861A		—	8.0	
Rise Time	Conditions for MPF4857,A, MPF4860,A:	MPF4856,A, MPF4859,A	t_r	—	3.0	ns
		MPF4857,A, MPF4860,A		—	4.0	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc,	MPF4858, MPF4861		—	10	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −6.0 Vdc)	MPF4858A, MPF4861A		—	8.0	
Turn-Off Time		MPF4856, MPF4859	t_{off}	—	25	
	Conditions for MPF4858,A, MPF4861,A:	MPF4856A, MPF4859A		—	20	ns
		MPF4857, MPF4860		—	50	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc,	MPF4857A, MPF4860A		—	40	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −4.0 Vdc)	MPF4858, MPF4861		—	100	
		MPF4858A; MPF4861A		—	80	

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.
(2) The $I_{D(on)}$ values are nominal; exact values vary slightly with transistor parameters.

6

U308
U309
U310

CASE 27-02, STYLE 4
TO-52 (TO-206AC)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

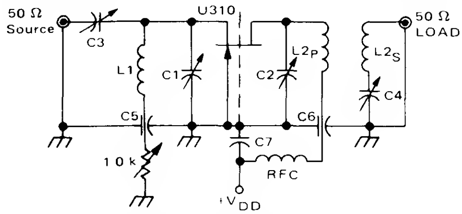
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μA, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	V
Gate Reverse Current (V_{GS} = −15 V) (V_{GS} = 0, T_A = 125°C)		I_{GSS}	— —	— —	−150 −150	pA nA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 nA)	U308 U309 U310	$V_{GS(off)}$	−1.0 −1.0 −2.5	— — —	−6.0 −4.0 −6.0	V
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 10 V, V_{GS} = 0)	U308 U309 U310	I_{DSS}	12 12 24	— — —	60 30 60	mA
Gate-Source Forward Voltage (I_G = 10 mA, V_{DS} = 0)		$V_{GS(f)}$	—	—	1.0	V
SWITCHING CHARACTERISTICS						
Common-Gate Forward Transconductance(1) (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	U308 U309 U310	g_{fg}	10 10 10	— — —	20 20 18	mmhos
Common-Gate Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)		g_{og}	—	150	—	μmhos
Drain-Gate Capacitance (V_{GS} = −10 V, V_{DS} = 10 V, f = 1.0 MHz)		C_{gd}	—	—	2.5	pF
Gate-Source Capacitance (V_{GS} = −10 V, V_{DS} = 10 V, f = 1.0 MHz)		C_{gs}	—	—	5.0	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 10 V, I_D = 10 mA, f = 100 Hz)		$\overline{e_n}$	—	10	—	$nV/\sqrt{Hz}$

(1) Pulse test duration = 2.0 ms.
(2) See Figures 10 and 11 for Noise Figure and Power Gain information.

FIGURE 1 – 450 MHz COMMON-GATE AMPLIFIER TEST CIRCUIT



C1 = C2 = 0.8 – 10 pF JFD #MVM010W
C3 = C4 = 8 35 pF Erie #539 002D
C5 = C6 = 5000 pF Erie (2443 000)
C7 = 1000 pF, Allen Bradley #FA5C.
RFC = 0.33 μH Miller #9230 30.
L1 = One Turn #16 Cu, 1/4" I.D. (Air Core)
L2P = One Turn #16 Cu, 1/4" I.D. (Air Core).
L2S = One Turn #16 Cu, 1/4" I.D. (Air Core).

6

FIGURE 2 – DRAIN CURRENT and TRANSFER CHARACTERISTICS versus GATE-SOURCE VOLTAGE

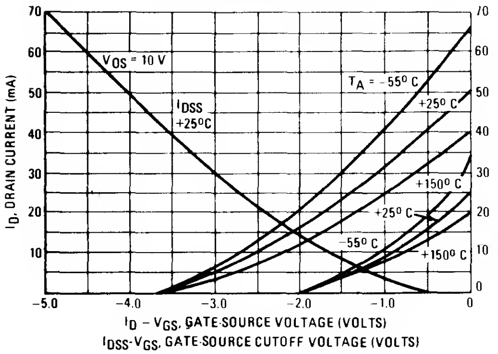


FIGURE 3 – FORWARD TRANSCONDUCTANCE versus GATE-SOURCE VOLTAGE

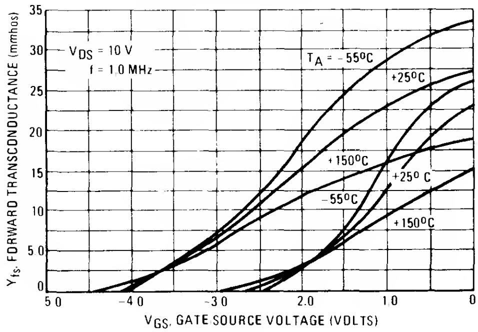


FIGURE 4 – COMMON-SOURCE OUTPUT ADMITTANCE and FORWARD TRANSCONDUCTANCE versus DRAIN CURRENT

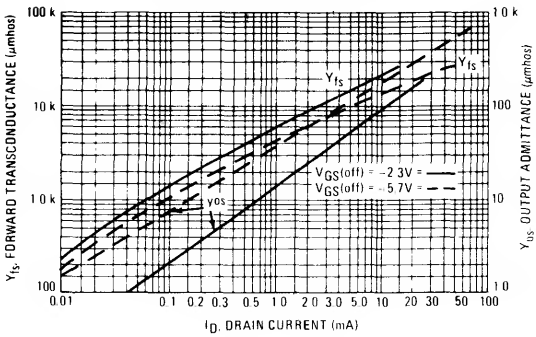


FIGURE 5 – ON RESISTANCE and JUNCTION CAPACITANCE versus GATE-SOURCE VOLTAGE

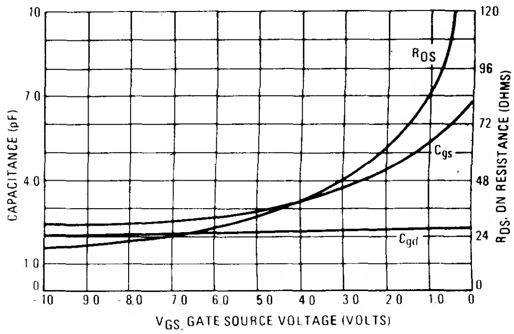


FIGURE 6 – COMMON-GATE Y PARAMETER MAGNITUDE versus FREQUENCY

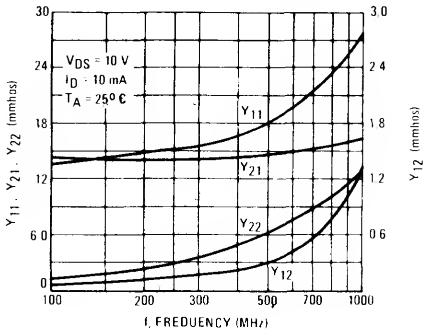


FIGURE 7 – COMMON-GATE S PARAMETER MAGNITUDE versus FREQUENCY

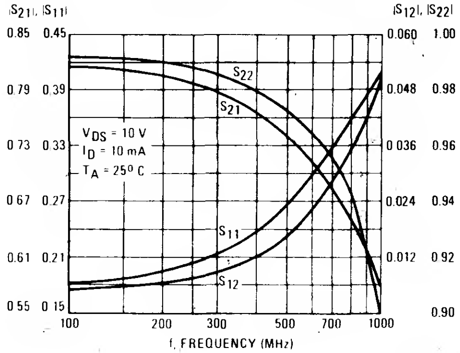


FIGURE 8 – COMMON-GATE Y PARAMETER PHASE-ANGLE versus FREQUENCY

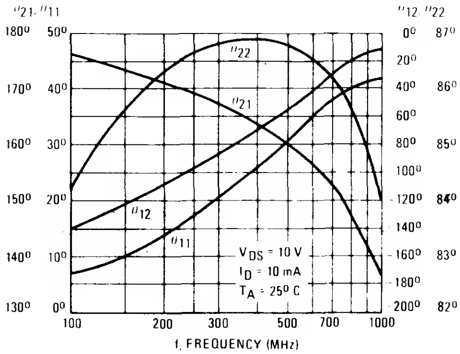


FIGURE 9 – S PARAMETER PHASE-ANGLE versus FREQUENCY

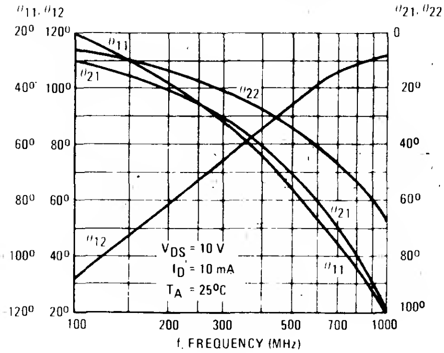


FIGURE 10 – NOISE FIGURE and POWER GAIN versus DRAIN CURRENT

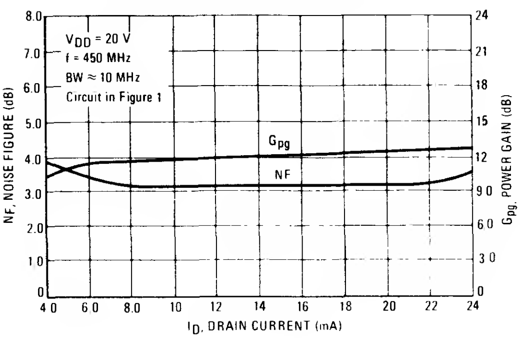


FIGURE 11 – NOISE FIGURE and POWER GAIN versus FREQUENCY

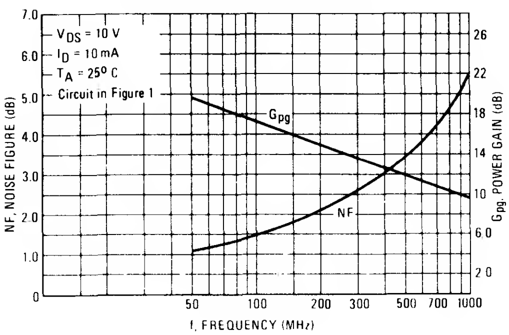
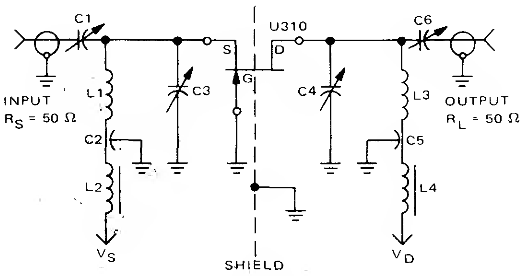


FIGURE 12 – 450 MHz IMD EVALUATION AMPLIFIER



B_W (3dB) - 36.5 MHz
I_D - 10 mAdc
V_{DS} 20 Vdc
Device case grounded
IM test tones – f1 = 449.5 MHz, f2 = 450.5 MHz

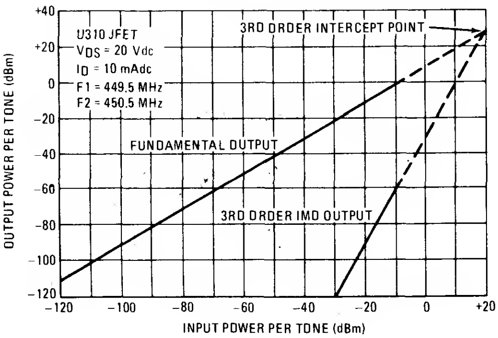
C1 = 1-10 pf Johanson Air variable trimmer.
C2, C5 = 100 pf feed thru button capacitor
C3, C4, C6 = 0.5-6 pf Johanson Air variable trimmer.

L1 = 1/8" x 1/32" x 1 5/8" copper bar
L2, L4 = Ferroxcube Vk200 choke.
L3 = 1/8" x 1/32" x 1 7/8" copper bar.

Amplifier power gain and IMD products are a function of the load impedance. For the amplifier design shown above with C4 and C6 adjusted to reflect a load to the drain resulting in a nominal power gain of 9 dB, the 3rd order intercept point (IP) value is 29 dBm. Adjusting C4, C6 to provide larger load values will result in higher gain, smaller bandwidth and lower IP values. For example, a nominal gain of 13 dB can be achieved with an intercept point of 19 dBm.

6

FIGURE 13 – TWO TONE 3RD ORDER INTERCEPT POINT



Example of intercept point plot use:
Assume two in-band signals of -20 dBm et the amplifier input. They will result in a 3rd order IMD signal at the output of -90 dBm. Also, each signal level et the output will be -11 dBm, showing an amplifier gain of 9.0 dB and an intermoduletion retio (IMR) capability of 79 dB. The gein and IMR values apply only for signal levels below compression.

RF Transistors

7

2N2857
2N3839

2N2857
JAN, JTX, JTXV AVAILABLE
CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	40	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.72	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

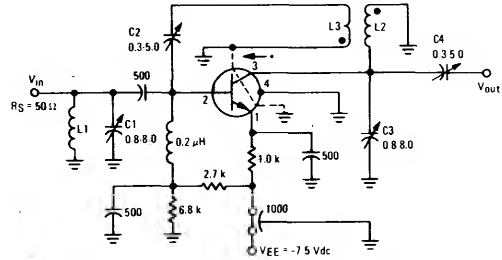
7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 3.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)		$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	 Both Types 2N3839	I_{CBO}	 — —	 — —	 0.01 1.0	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	30	—	150	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	 2N2857 2N3839	f_T	 1000 1000	 — —	 1900 2000	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)		C_{cb}	—	0.7	1.0	pF
Small Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{fe}	50	—	220	—
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	 2N2857 2N3839	$r_b'C_c$	 4.0 1.0	 — —	 15 15	ps
Noise Figure (Figure 1) (I_E = 0.1 mAdc, V_{CE} = 1.0 Vdc, R_S = 50 ohms, f = 450 MHz)(2) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 450 MHz)	 Both Types 2N2857 2N3839	NF	 — — —	 5.8 4.1 —	 — 4.5 3.9	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) (I_E = 0.1 mAdc, V_{CE} = 1.0 Vdc, f = 450 MHz, R_S = 50Ω))(2) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz, R_S = 50Ω)		G_{pe}	 — 12.5	 11 —	 — 19	dB
Power Output (Figure 2) (I_E = 12 mAdc, V_{CB} = 10 Vdc, f = 500 MHz)		P_{out}	30	—	—	mW

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(2) Micro-Power Specifications.
*Indicates Data in addition to JEDEC Requirements.

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



Capacitance values in pF

L1, L2 – Silver-plated brass rod, 1 1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface

L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.

– External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

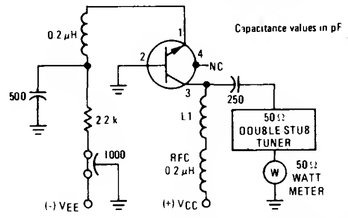
(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

FIGURE 2 – TEST CIRCUIT FOR OSCILLATOR POWER OUTPUT



L1 – 3 turns #16 AWG wire, 3/8" O.D. 1 1/4" long

FIGURE 3 – NOISE FIGURE versus FREQUENCY

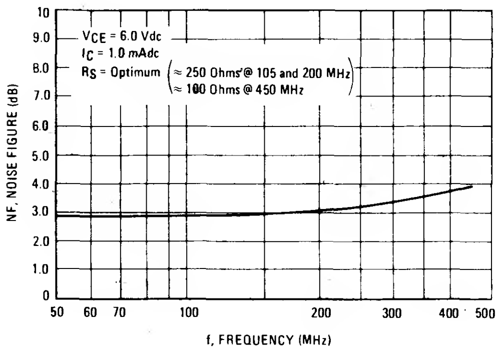


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

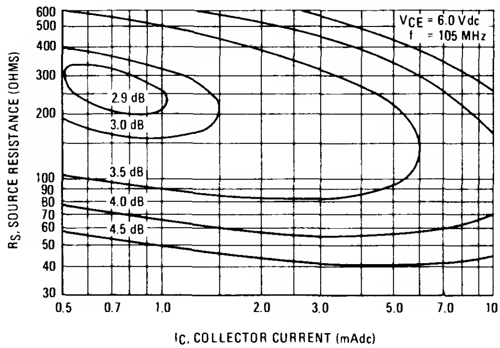


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

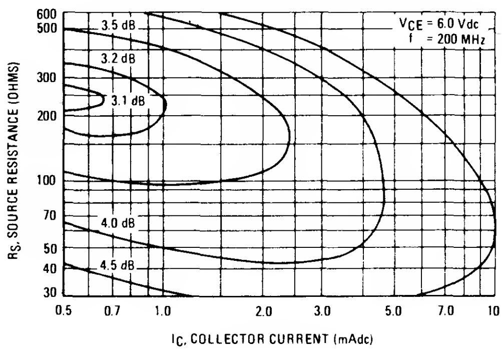


FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

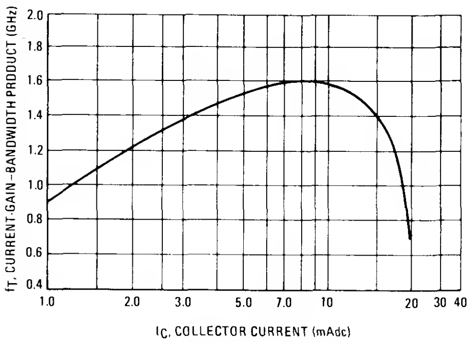


FIGURE 7 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

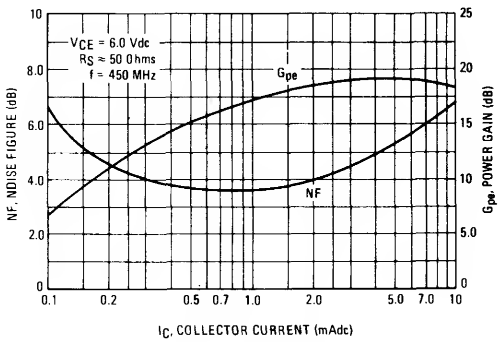


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

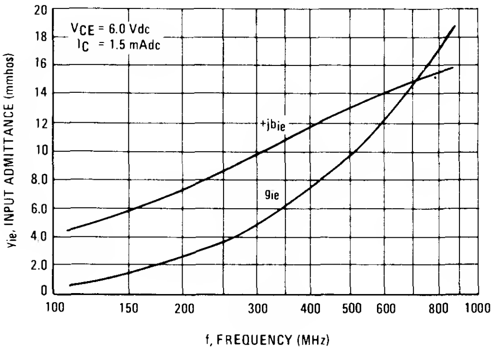


FIGURE 9 – OUTPUT ADMITTANCE versus FREQUENCY

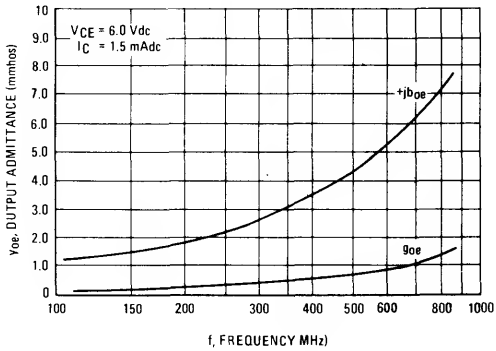


FIGURE 10 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

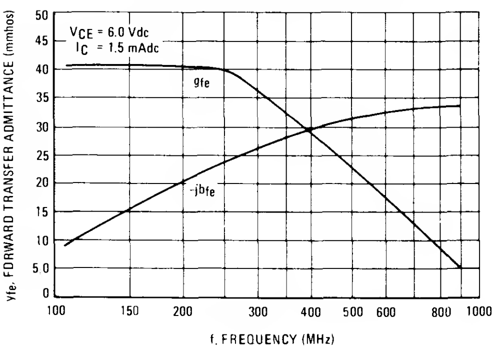


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

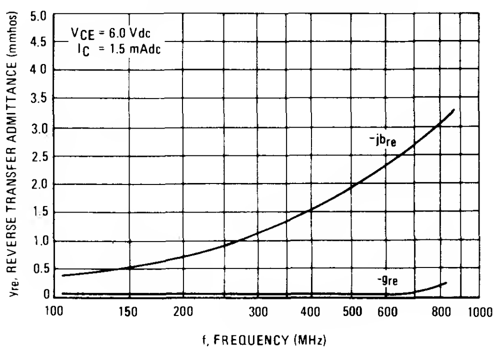


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FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

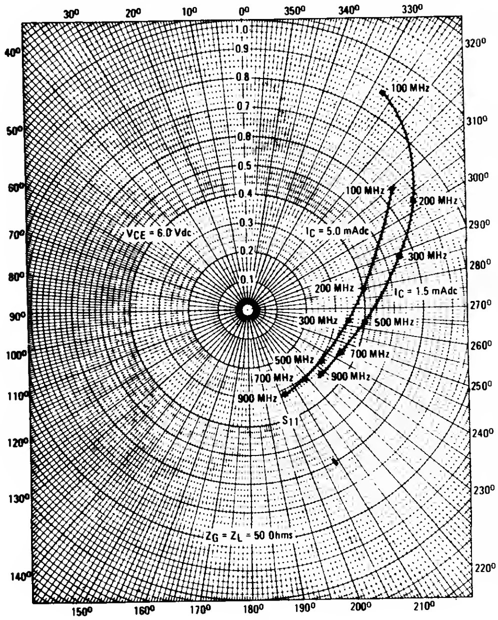


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

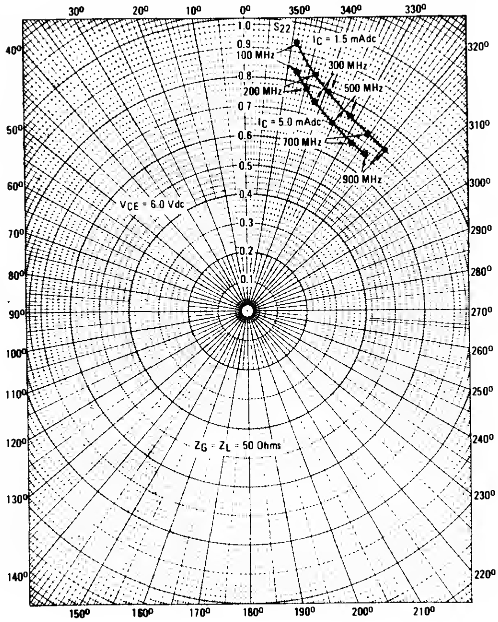


FIGURE 14 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

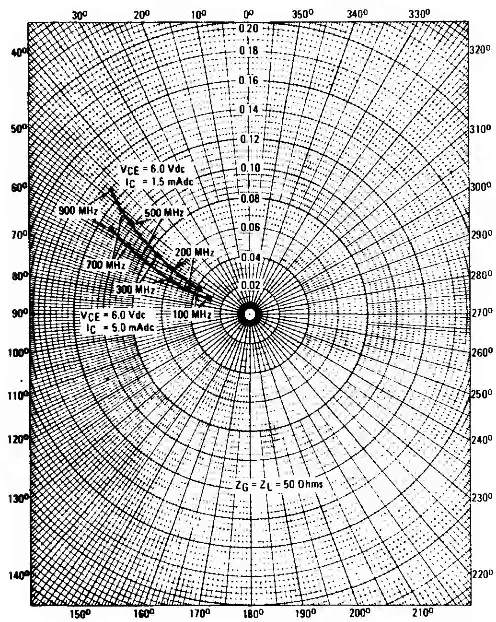


FIGURE 15 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

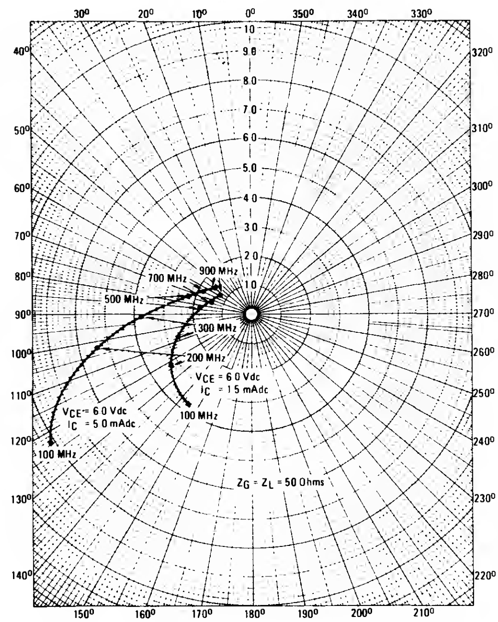
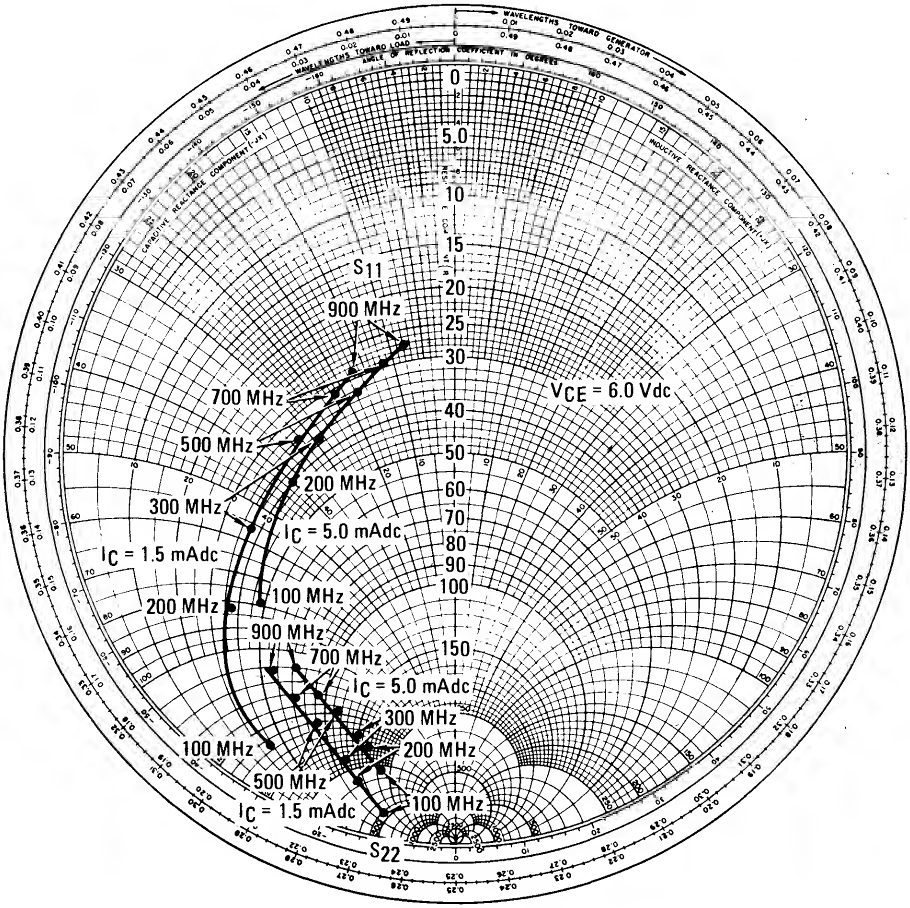


FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



2N3553

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) ($I_C = 200$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $I_B = 0$)	I_{CEO}	—	—	0.1	mAdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 1.5$ Vdc, $T_C = 200°C$) ($V_{CE} = 65$ Vdc, $V_{BE(off)} = 1.5$ Vdc)	I_{CEX}	 — —	 — —	 5.0 1.0	mAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 250$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	10	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 250$ mAdc, $I_B = 50$ mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 100$ mAdc, $V_{CE} = 28$ Vdc, f = 100 MHz)	f_T	—	500	—	MHz
Output Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	8.0	10	pF
FUNCTIONAL TEST (FIGURE 2)					
Amplifier Power Gain ($V_{CE} = 28$ Vdc, $P_{out} = 2.5$ Watts, f = 175 MHz)	G_{pe}	10	—	—	dB
Collector Efficiency ($V_{CE} = 28$ Vdc, $P_{out} = 2.5$ Watts, f = 175 MHz)	η	50	—	—	%
Power Input ($V_{CE} = 28$ Vdc, $P_{out} = 2.5$ Watts, f = 175 MHz)	P_{in}	—	—	0.25	Watt

(1) Pulsed thru a 25 mH inductor.

FIGURE 1 – OUTPUT POWER versus FREQUENCY

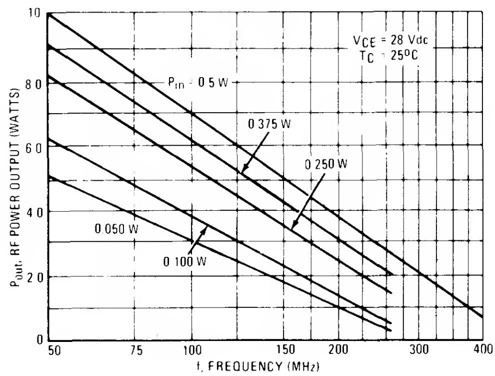
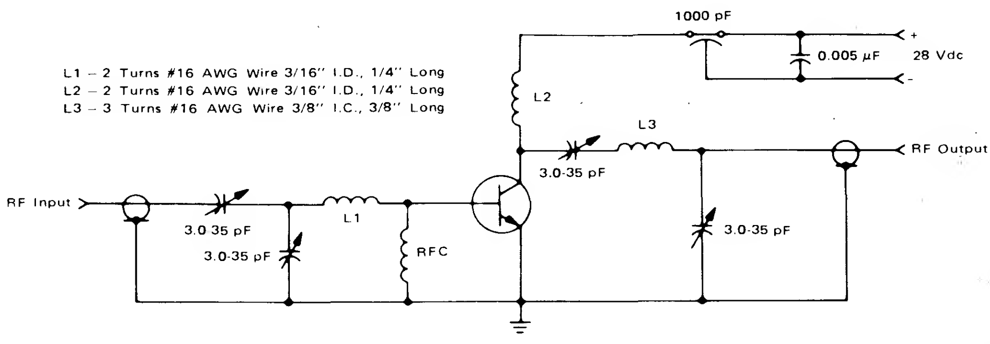


FIGURE 2 – 175 MHz TEST CIRCUIT SCHEMATIC



2N3839 For Specifications, See 2N2857 Data.

2N3866
2N3866A

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

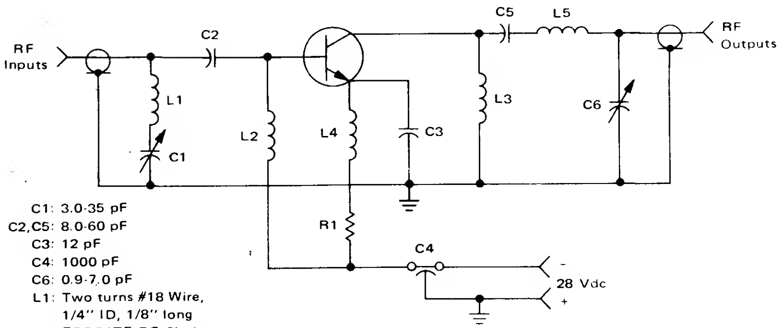
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 10 Ω)		$V_{CER(sus)}$	55	—	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{CEO(sus)}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)		I_{CEO}	—	0.02	mAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = −1.5 Vdc (Rev.), T_C = 200°C) (V_{CE} = 55 Vdc, V_{BE} = −1.5 Vdc (Rev.)		I_{CEX}	 — —	 5.0 0.1	mAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)		I_{EBO}	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 360 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	 Both 2N3866 2N3866A	h_{FE}	 5.0 10 25	 — 200 200	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	 2N3866 2N3866A	f_T	 500 800	 — —	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.0	pF
FUNCTIONAL TEST (FIGURE 1)					
Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)		G_{pe}	10	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)		η	45	—	%

7

FIGURE 1 – 400 MHz TEST CIRCUIT SCHEMATIC



C1: 3.0-35 pF
C2,C5: 8.0-60 pF
C3: 12 pF
C4: 1000 pF
C6: 0.9-7.0 pF
L1: Two turns #18 Wire, 1/4" ID, 1/8" long
L2: FERRITE RF Choke, One Turn, z = 450 Ohms
L3,L4: RF Choke, 0.1 μH
L5: 2-3/4 Turns, #18 Wire, 1/4" ID, 3/16" long
R1: 5.6 Ohms

FIGURE 2 – POWER OUTPUT versus FREQUENCY (Class C)

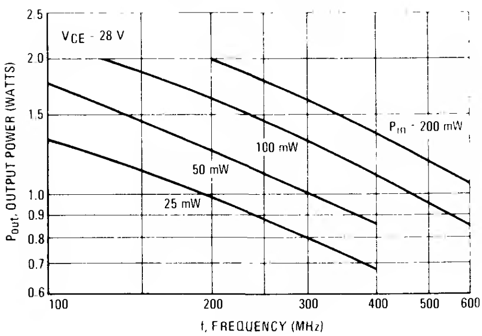


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

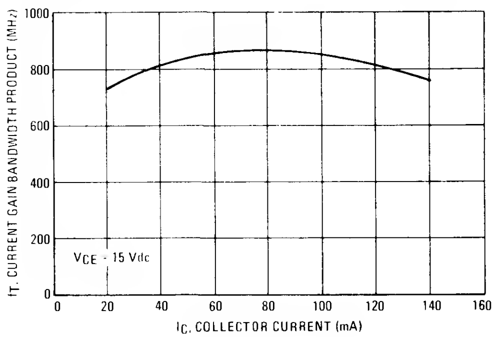


FIGURE 4 – COLLECTOR-BASE TIME CONSTANT

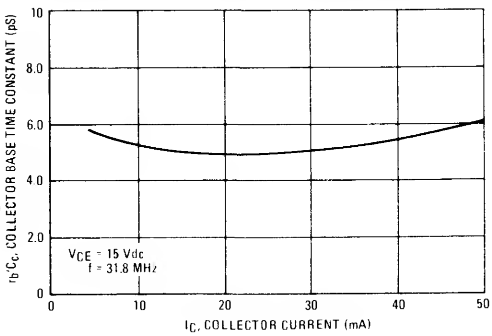


FIGURE 5 – OUTPUT CAPACITANCE

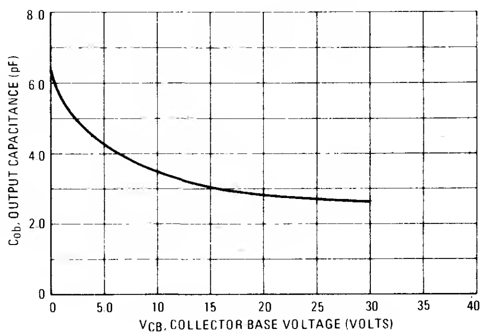


FIGURE 6 — OUTPUT POWER versus INPUT POWER (CLASS C)

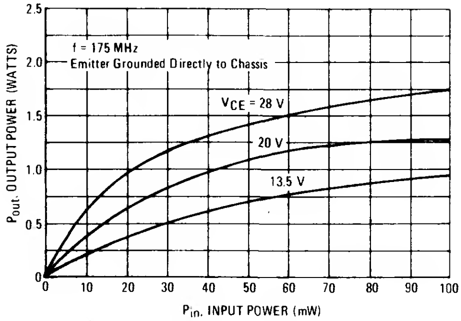


FIGURE 7 — SMALL-SIGNAL CURRENT GAIN

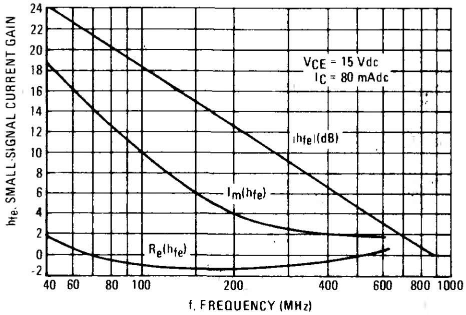


FIGURE 8 — LARGE-SIGNAL SERIES EQUIVALENT IMPEDANCES

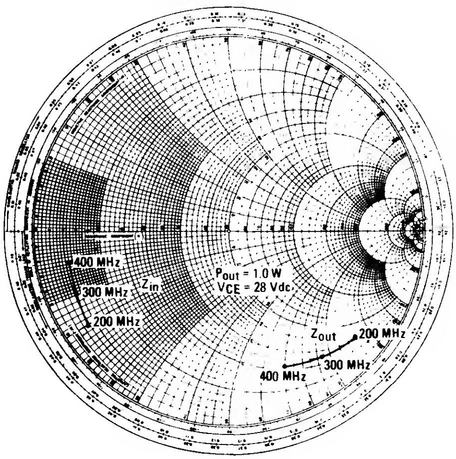


FIGURE 9 — S_{11} AND S_{22} versus FREQUENCY

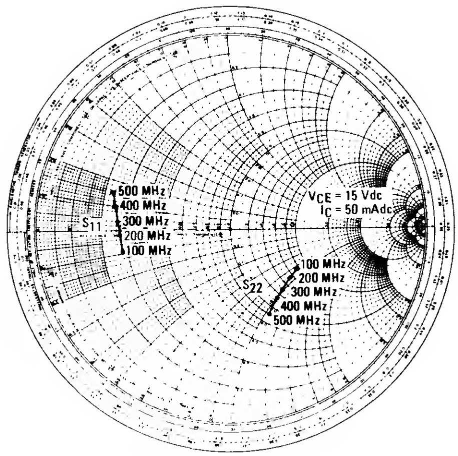


FIGURE 10 – S_{21} versus FREQUENCY

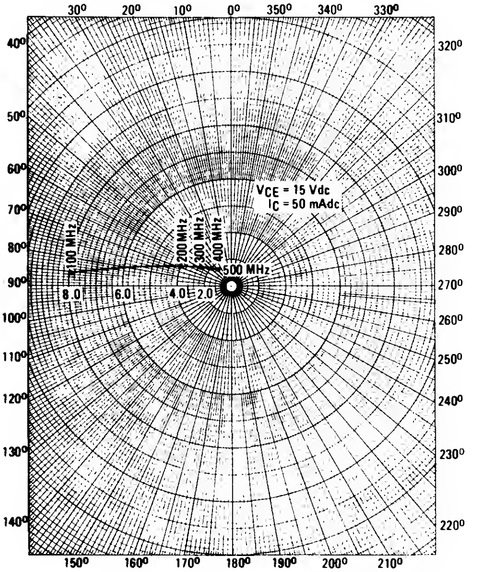
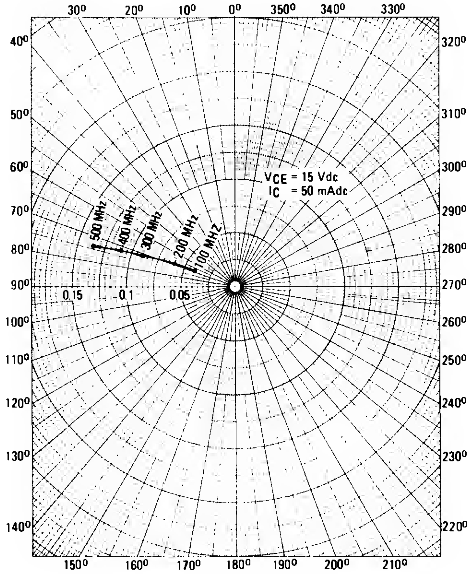


FIGURE 11 – S_{12} versus FREQUENCY



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2N3948

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.1 100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	15	—	—
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_E = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	700	—	MHz
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.5	pF
FUNCTIONAL TEST (FIGURE 1)				
Power Gain (V_{CC} = 13.6 Vdc, f = 400 MHz, P_{in} = 0.25 W)	G_{pe}	6.0	—	dB
Output Power (V_{CC} = 13.6 Vdc, f = 400 MHz, P_{in} = 0.25 W)	P_{out}	1.0	—	Watt
Collector Efficiency (V_{CC} = 13.6 Vdc, f = 400 MHz, P_{in} = 0.25 W)	η	45	—	%

FIGURE 1 – 400 MHz RF AMPLIFIER TEST CIRCUIT

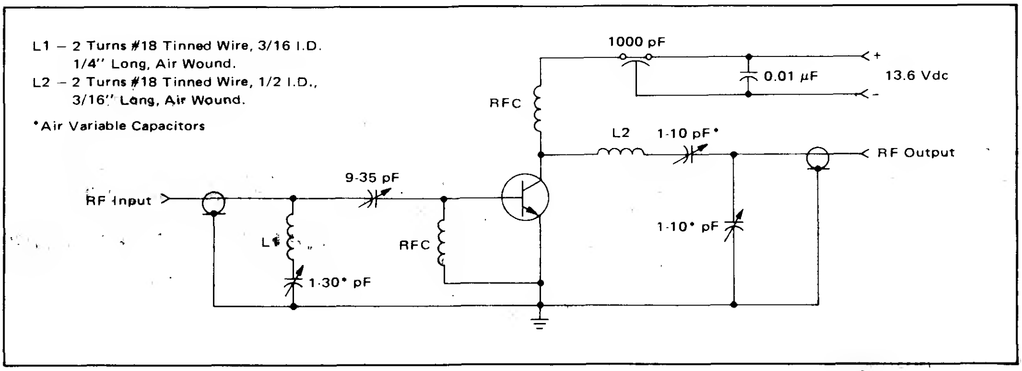


FIGURE 2 – OUTPUT POWER versus FREQUENCY

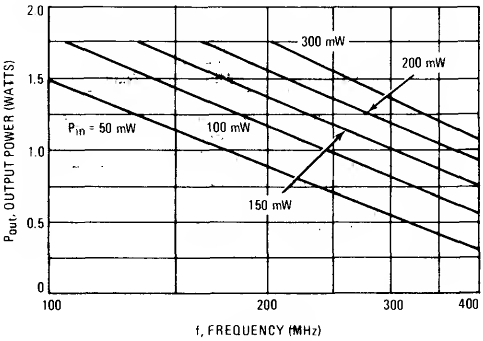
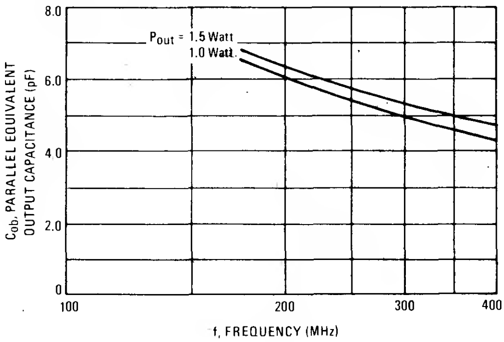


FIGURE 3 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3959
2N3960

JAN, JTX, JTXV AVAILABLE
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.3	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	750 4.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.233	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.436	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 10$ Vdc, $V_{EB} = 2.0$ Vdc) ($V_{CE} = 10$ Vdc, $V_{EB} = 2.0$ Vdc, $T_A = 150°C$)		I_{CEX}	 — —	 — —	 0.005 5.0	μAdc
Collector Forward Current ($V_{CE} = 5.0$ Vdc, $V_{BE} = 0.4$ Vdc)		I_{CEX}	—	—	1.0	μAdc
Base Cutoff Current ($V_{CE} = 10$ Vdc, $V_{EB} = 2.0$ Vdc)		I_{BL}	—	—	0.005	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 25 40 25	 — — —	 — 400 —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)		$V_{CE(sat)}$	 — —	 — —	 0.2 0.3	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	 — —	 — —	 0.8 1.0	Vdc
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 4.0$ Vdc, f = 100 MHz) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz) ($I_C = 30$ mAdc, $V_{CE} = 4.0$ Vdc, f = 100 MHz)	 2N3959 2N3960 2N3959 2N3960 2N3959 2N3960	f_T	 1000 1300 1300 1600 1000 1200	 — — — — — —	 — — — — — —	MHz
Output Capacitance ($V_{CB} = 4.0$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	2.0	2.5	pF

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 MHz)		C_{ibo}	—	1.5	2.5	pF
Collector Base Time Constant		$rb'C_C$				ps
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc)	2N3959		—	—	30	
	2N3960		—	—	50	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3959		—	—	25	
	2N3960		—	—	40	
(I_C = 30 mAdc, V_{CE} = 4.0 Vdc)	2N3959		—	—	30	
	2N3960		—	—	50	

SWITCHING CHARACTERISTICS (FIGURE 7)

Characteristic		Symbol	Min	Typ	Max	Unit
Turn-On Delay Time		$t_{d(on)}$				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)			—	2.4	—	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)			—	2.0	—	
Rise Time		t_r				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)	Both Devices		—	3.0	—	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)	2N3959		—	2.2	—	
	2N3960		—	1.7	—	
Turn-Off Delay Time		$t_{d(off)}$				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)			—	1.6	—	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)			—	1.6	—	
Fall Time		t_f				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)	Both Devices		—	3.3	—	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)	2N3959		—	2.3	—	
	2N3960		—	1.9	—	

7

FIGURE 1 – TYPICAL DC CURRENT GAIN

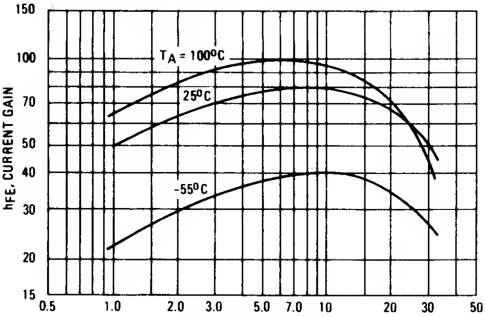


FIGURE 2 – TYPICAL CURRENT-GAIN – BANDWIDTH PRODUCT

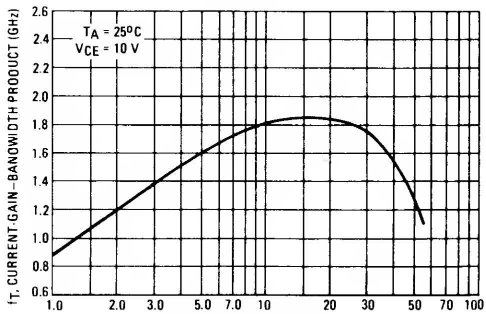


FIGURE 3 – TYPICAL COLLECTOR-BASE TIME CONSTANT

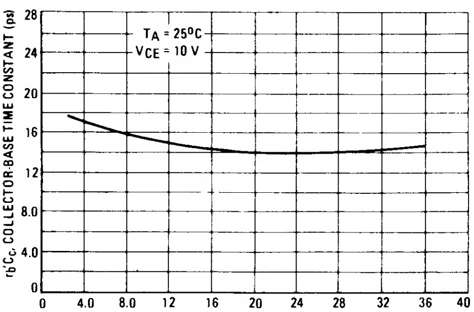
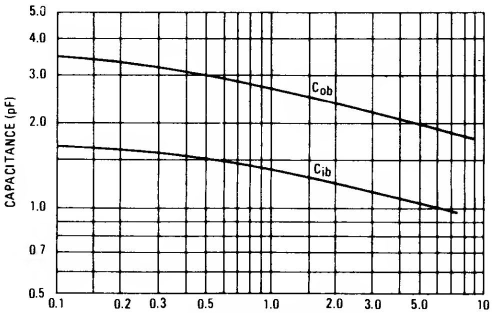


FIGURE 4 – TYPICAL JUNCTION CAPACITANCE



TURN-ON AND TURN-OFF TIMES

FIGURE 5 – V_{out} = 1.0 Vdc

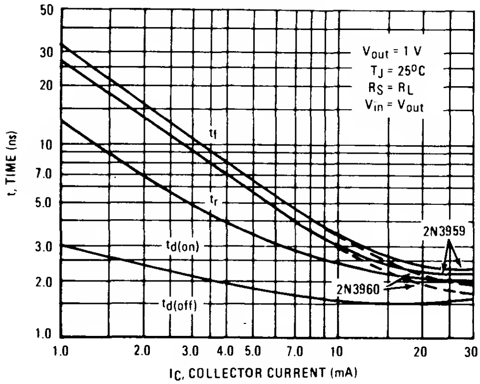


FIGURE 6 – V_{out} = 2.0 Vdc

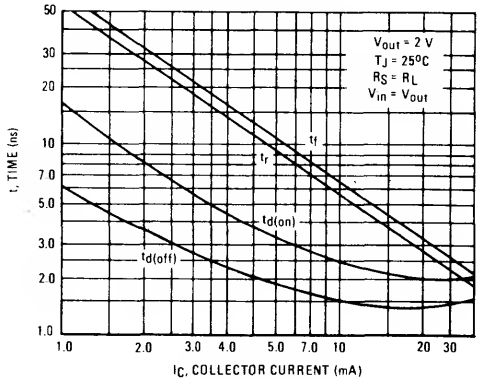
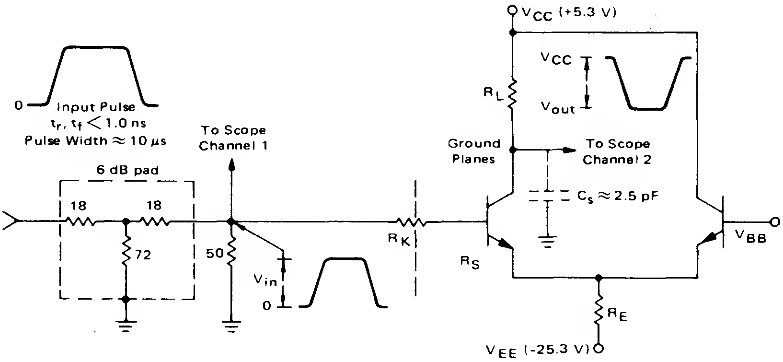


FIGURE 7 – SWITCHING TIMES TEST CIRCUIT



This test set up is designed to simulate a cascade of identical stages. ∴The source resistance (R_S) equals the load resistance (R_L). Values used in the test are shown in the table.

For V_{in} = V_{out} = 1 V, V_{BB} = +0.5 V, R_L & R_K values appropriately reduced.

V_{in} = V_{out} = 2 volts, V_{BB} = +1.0V			
I_C (mA)	R_E (kΩ)	R_L (Ω)	R_K (Ω)
1.0	24.0	2.0 k	2.0 k
3.0	8.2	680	680
10	2.4	200	180
30	0.8	68	36

2N4427

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Base Current	I_B	400	mAdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, R_{BE} = 10 ohms)	$V_{CER(sus)}$	40	—	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	—	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, I_B = 0)	I_{CEO}	—	0.02	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = −1.5 Vdc) (V_{CE} = 12 Vdc, V_{BE} = −1.5 Vdc, T_C = +150°C)	I_{CEV}	 — —	 0.1 5.0	mAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc) (I_C = 360 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 10 5.0	 200 —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF
FUNCTIONAL TEST (FIGURE 2)				
Common-Emitter Amplifier Power Gain (P_{in} = 100 mW, V_{CC} = 12 Vdc, f = 175 MHz)	G_{pe}	10	—	dB
Collector Efficiency (P_{out} = 1.0 W, V_{CC} = 12 Vdc, f = 175 MHz)	η	50	—	%
Power Input (P_{out} = 1.0 W, V_{CC} = 12 Vdc, f = 175 MHz)	P_{in}	—	100	mW

FIGURE 1 – POWER OUTPUT versus FREQUENCY

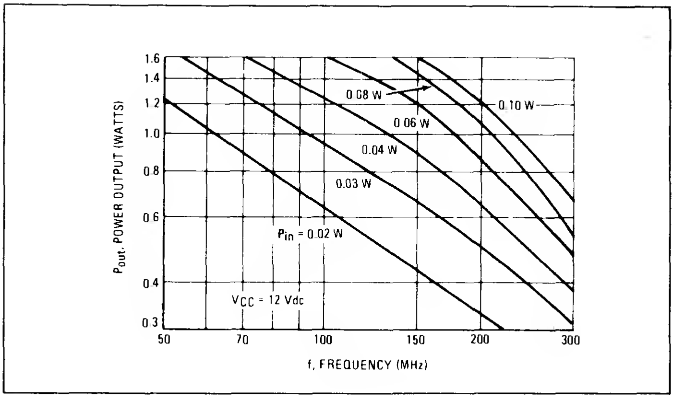
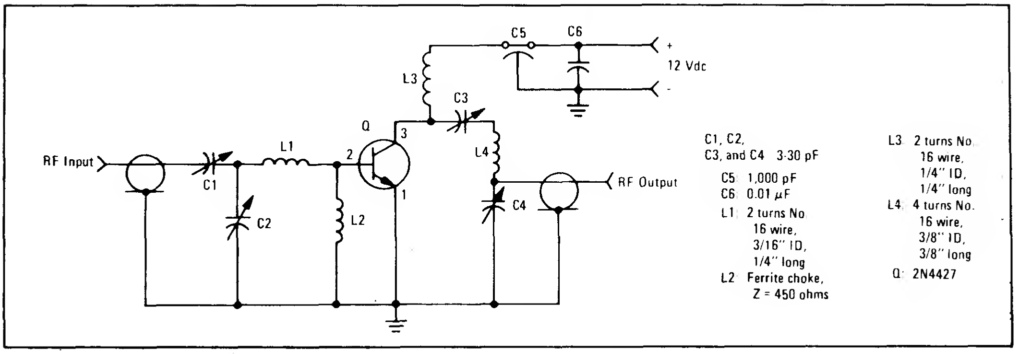


FIGURE 2 – 175 MHz RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST



2N4957
2N4958
2N4959
2N5829

2N4957
JAN, JTX, JTXV AVAILABLE
CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	 — —	 — —	 0.1 100	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	40	150	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) (I_E = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	 2N4957, 2N5829 2N4958, 2N4959	f_T	 1200 1000	 1600 1500	 2500 2500	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	0.4	0.8	pF
Small Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	—	200	—
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)		$r_b'C_c$	1.0	—	8.0	ps
Noise Figure (Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	 2N5829 2N4957 2N4958 2N4959	NF	 — — — —	 2.3 2.6 2.9 3.2	 2.5 3.0 3.3 3.8	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz)	 2N4957, 2N5829 2N4958 2N4959	G_{pe}	 17 16 15	 — — —	 25 25 25	dB

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – NOISE FIGURE AND POWER GAIN TEST CIRCUIT

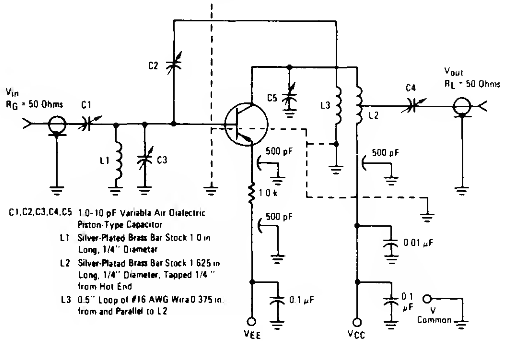


FIGURE 2 – UNILATERALIZED POWER GAIN versus FREQUENCY

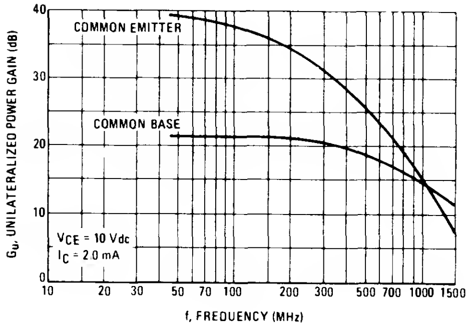


FIGURE 3 – NOISE FIGURE versus FREQUENCY

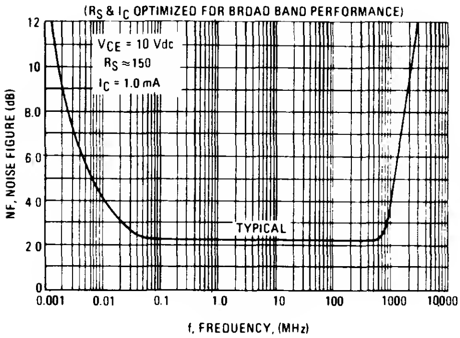


FIGURE 4 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

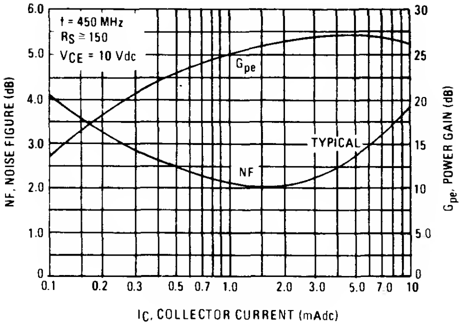


FIGURE 5 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

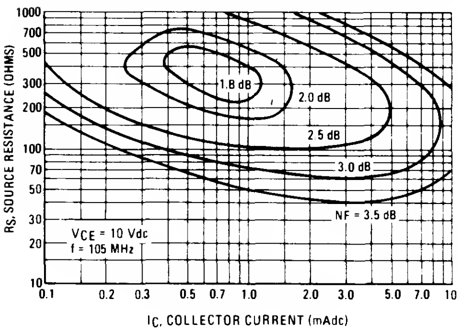
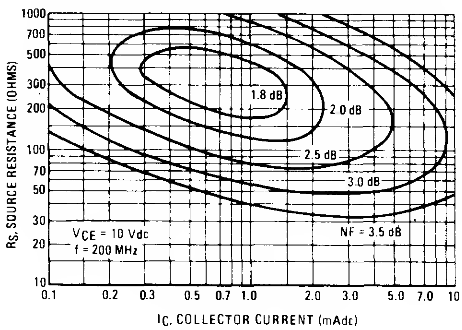


FIGURE 6 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT



7

COMMON EMITTER CIRCUIT DESIGN DATA

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 7 — TRANSDUCER GAIN versus FREQUENCY

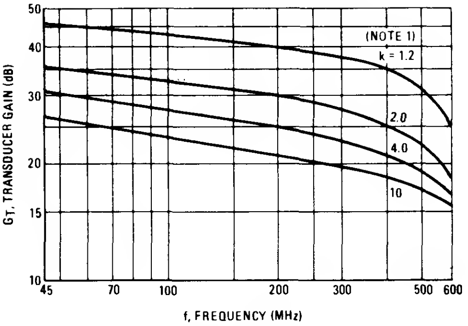


FIGURE 8 — LINVILL STABILITY FACTOR versus FREQUENCY

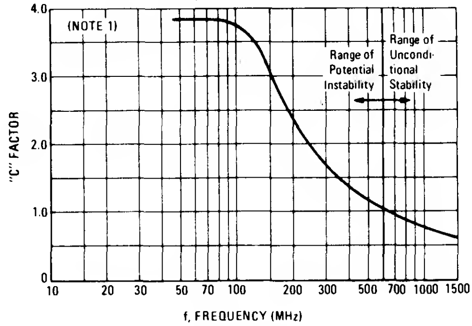


FIGURE 9 — LOAD ADMITTANCE versus FREQUENCY (REAL)

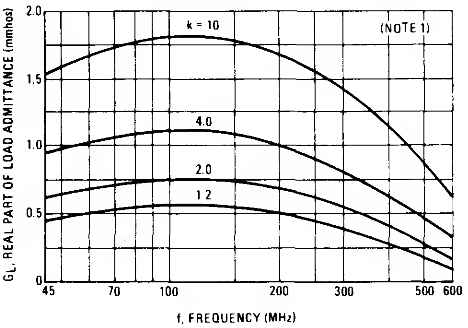


FIGURE 10 — LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

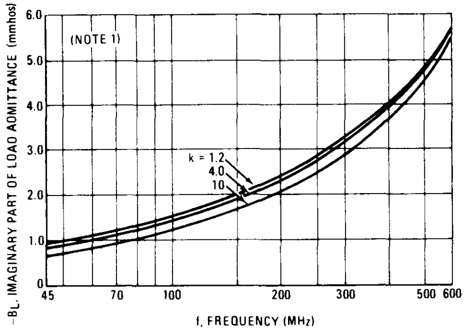


FIGURE 11 — SOURCE ADMITTANCE versus FREQUENCY (REAL)

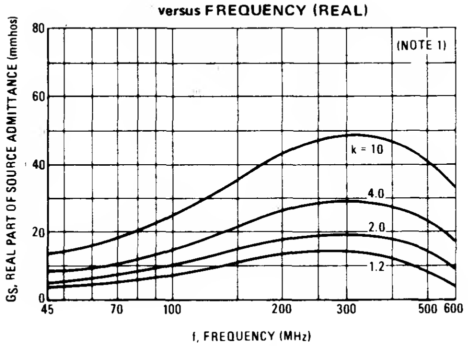
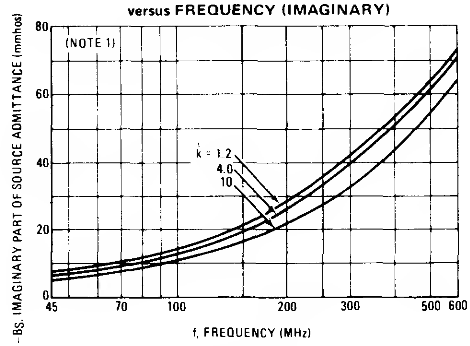


FIGURE 12 — SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)



NOTE 1

Figures 7 through 18 are included to assist the circuit designer in determining the stability of his particular circuit. Two stability criteria are given in these figures.

The Linvill "C" factor* is a measure of transistor stability when the input and output are terminated in the worst case (open circuit) condition. When "C" is less than 1.0, the circuit is unconditionally stable. When "C" is greater than 1.0, the circuit is potentially unstable.

The Stern "K" factor† has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN 215A.

* "Transistors and Active Circuits," Linvill and Gibbons, McGraw Hill, 1961

† "Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc I.R.E., March 1967

COMMON BASE CIRCUIT DESIGN DATA

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 13 – TRANSDUCER GAIN versus FREQUENCY

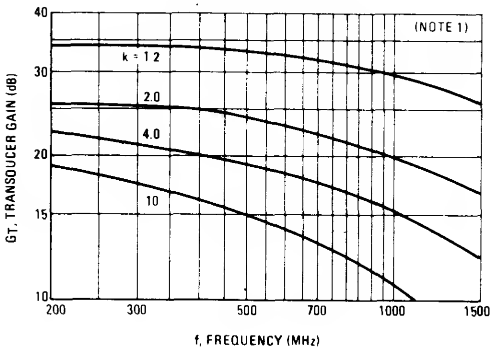


FIGURE 14 – LINVILL STABILITY FACTOR versus FREQUENCY

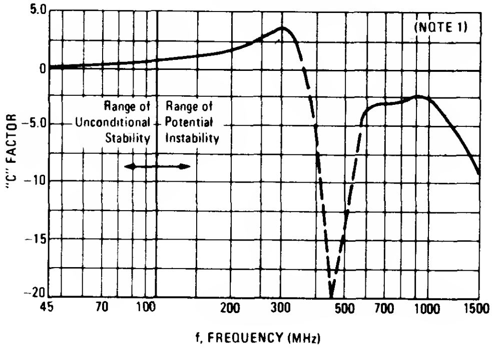


FIGURE 15 – LOAD ADMITTANCE versus FREQUENCY (REAL)

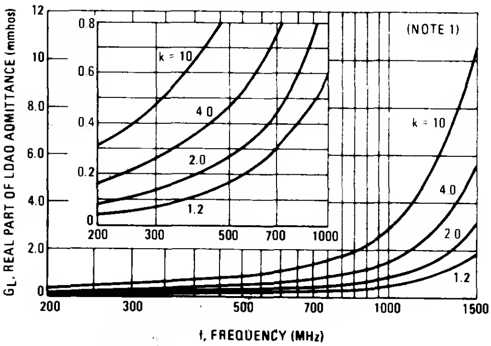


FIGURE 16 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

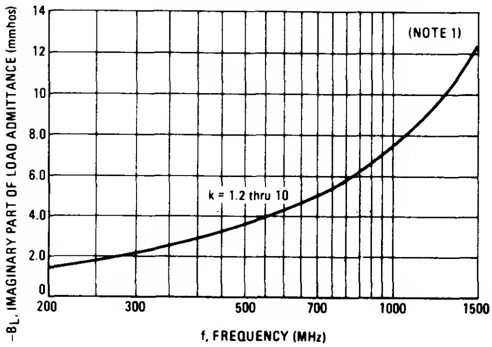


FIGURE 17 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

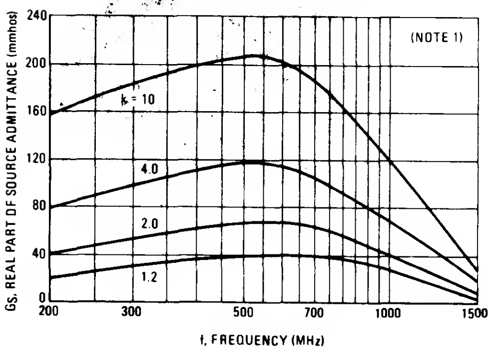
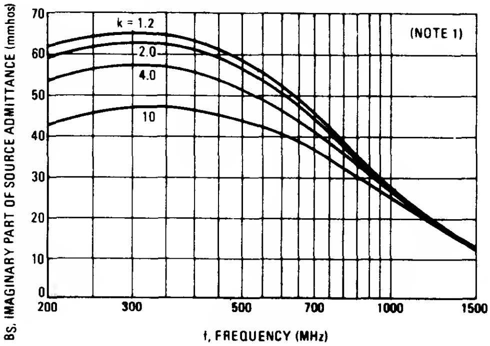


FIGURE 18 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)



7

FIGURE 19 – SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

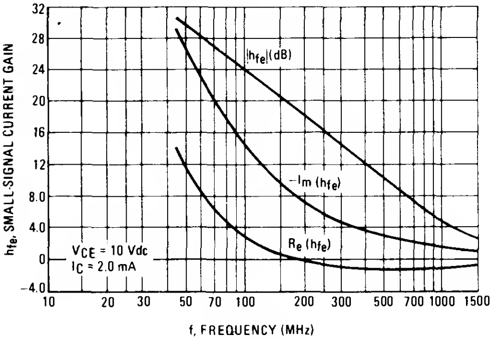


FIGURE 20 – POLAR h_{fe}

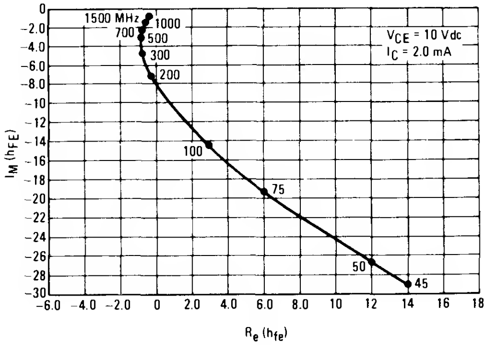


FIGURE 21 – f_T versus COLLECTOR CURRENT

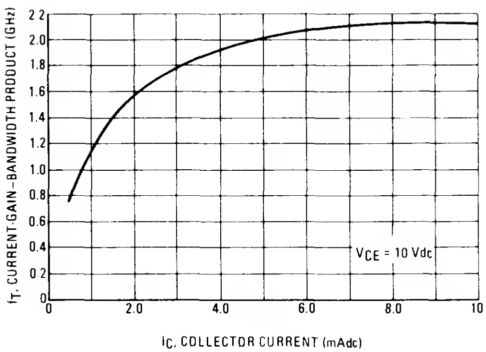


FIGURE 22 – DC CURRENT GAIN

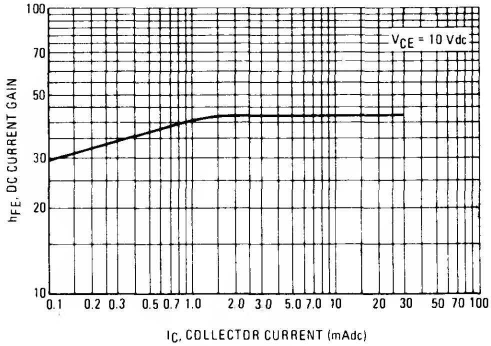


FIGURE 23 – CAPACITANCE

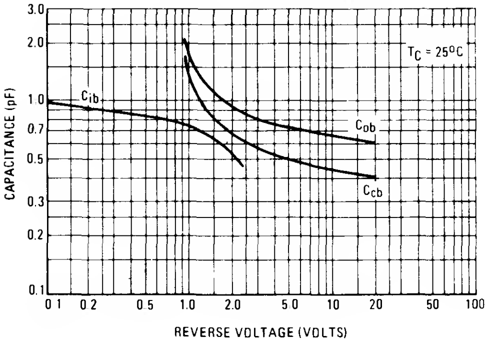
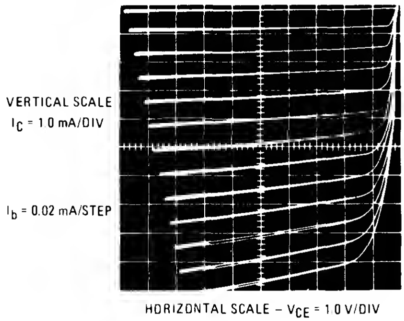
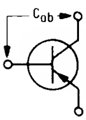
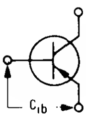


FIGURE 24 – COLLECTOR CHARACTERISTICS

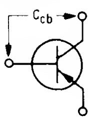




Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is open



Apply reverse bias between emitter and base and measure capacitance between these terminals. Collector is open



Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is guarded.

Y PARAMETERS versus CURRENT

(f = 450 MHz)

COMMON BASE	COMMON EMITTER
V_{CB} = 10 Vdc ——— V_{CB} = 15 Vdc — — —	V_{CE} = 10 Vdc ——— V_{CE} = 15 Vdc — — —

FIGURE 25 – INPUT ADMITTANCE

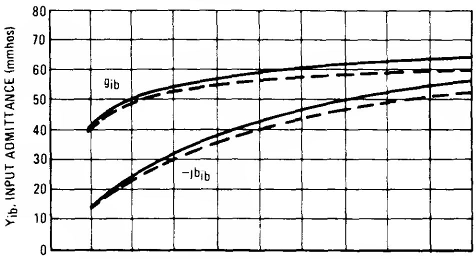


FIGURE 26 – INPUT ADMITTANCE

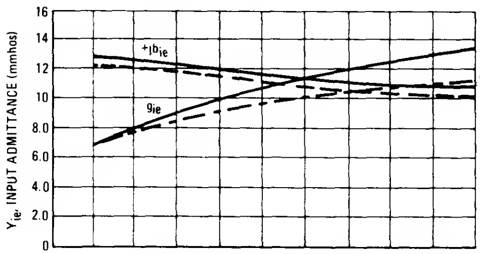


FIGURE 27 – FORWARD TRANSFER ADMITTANCE

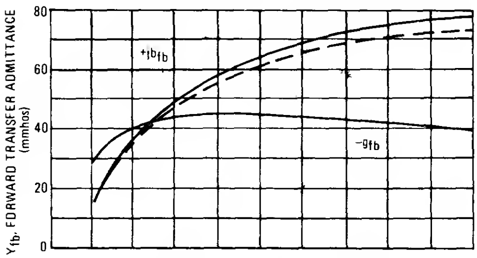


FIGURE 28 – FORWARD TRANSFER ADMITTANCE

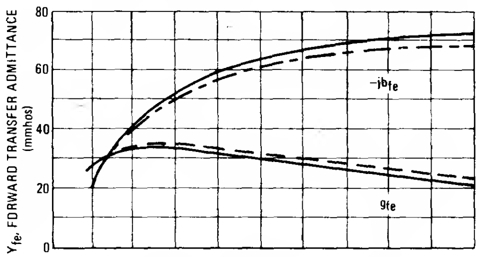


FIGURE 29 – OUTPUT ADMITTANCE

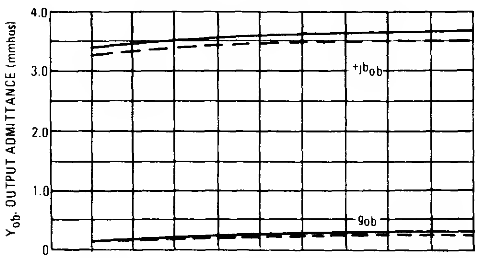


FIGURE 30 – OUTPUT ADMITTANCE

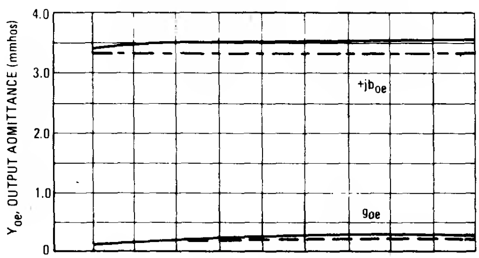


FIGURE 31 – REVERSE TRANSFER ADMITTANCE

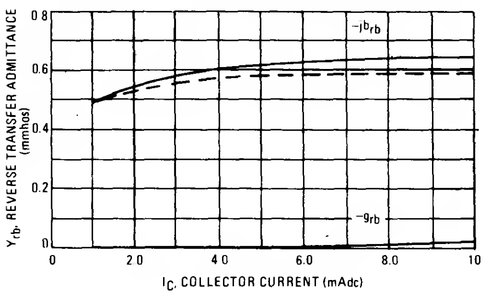
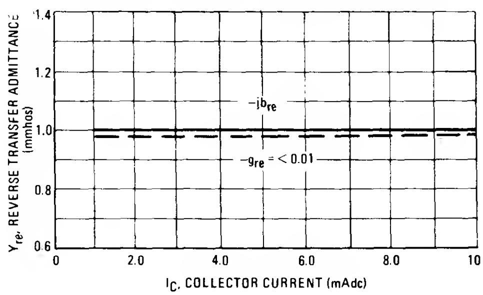


FIGURE 32 – REVERSE TRANSFER ADMITTANCE



7

COMMON BASE y PARAMETER VARIATIONS

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

y PARAMETERS versus FREQUENCY

FIGURE 33 – y_{ib} INPUT ADMITTANCE

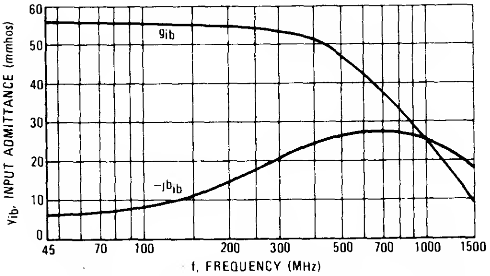


FIGURE 35 – y_{fb} FORWARD TRANSFER ADMITTANCE

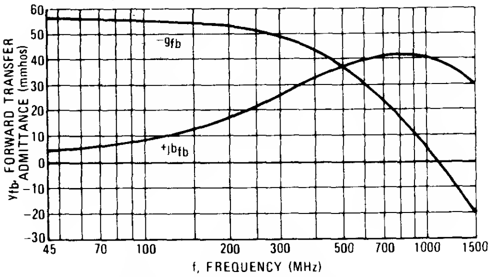


FIGURE 37 – y_{ob} OUTPUT ADMITTANCE

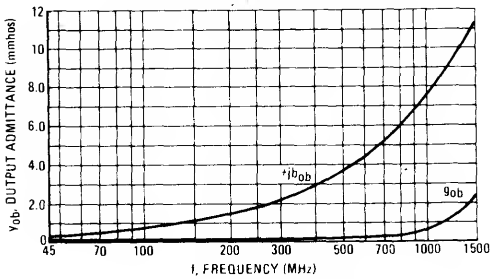
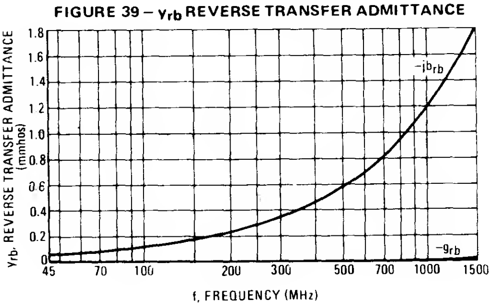


FIGURE 39 – y_{rb} REVERSE TRANSFER ADMITTANCE



POLAR y PARAMETERS versus FREQUENCY

FIGURE 34 – y_{ib} INPUT ADMITTANCE

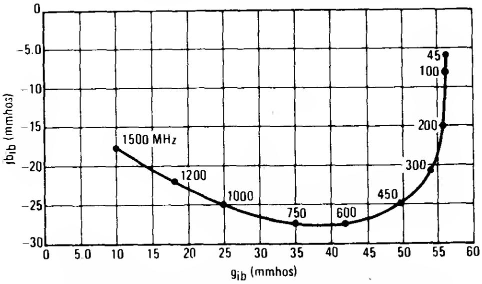


FIGURE 36 – y_{fb} FORWARD TRANSFER ADMITTANCE

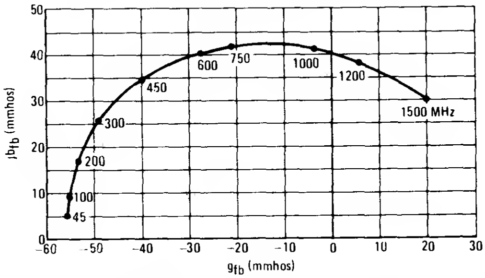


FIGURE 38 – y_{ob} OUTPUT ADMITTANCE

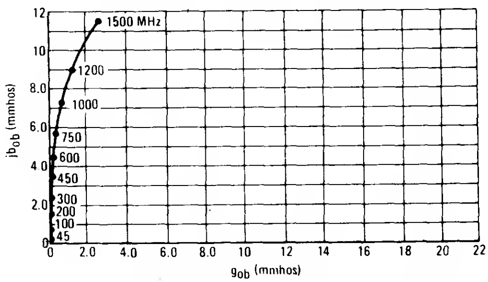
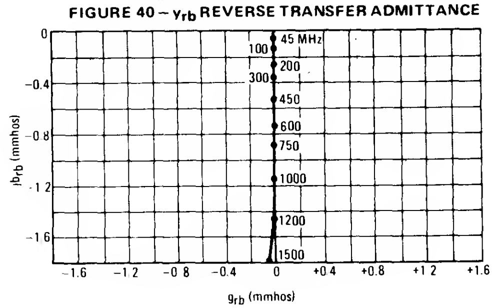


FIGURE 40 – y_{rb} REVERSE TRANSFER ADMITTANCE



COMMON EMITTER y PARAMETER VARIATIONS

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

y PARAMETERS versus FREQUENCY

FIGURE 41 – y_{ie} INPUT ADMITTANCE

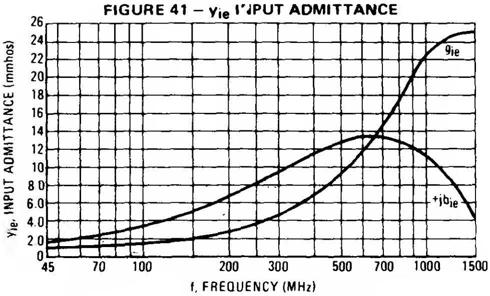


FIGURE 43 – y_{fe} FORWARD TRANSFER ADMITTANCE

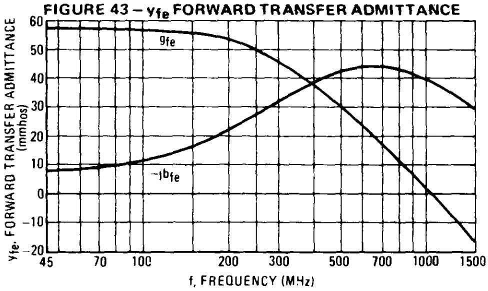


FIGURE 45 – y_{oe} OUTPUT ADMITTANCE

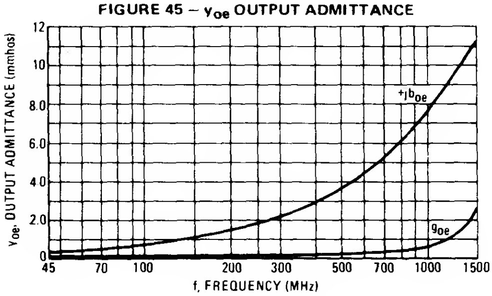
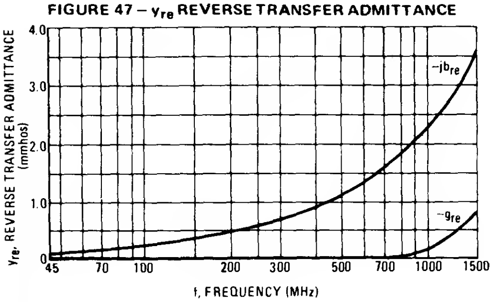


FIGURE 47 – y_{re} REVERSE TRANSFER ADMITTANCE



POLAR y PARAMETERS versus FREQUENCY

FIGURE 42 – y_{ie} INPUT ADMITTANCE

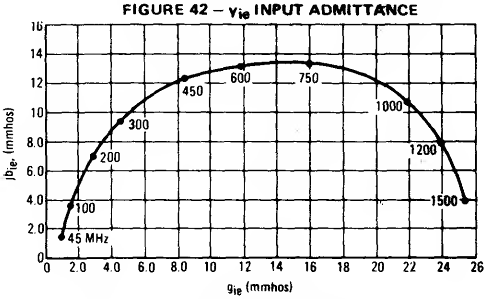


FIGURE 44 – y_{fe} FORWARD TRANSFER ADMITTANCE

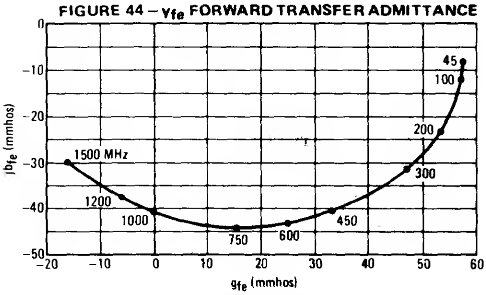


FIGURE 46 – y_{oe} OUTPUT ADMITTANCE

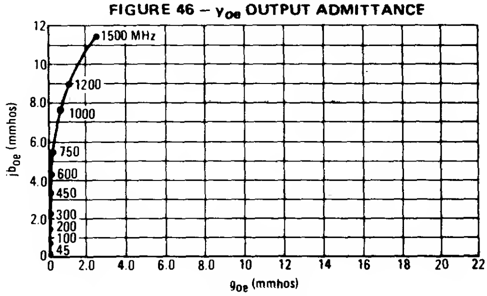
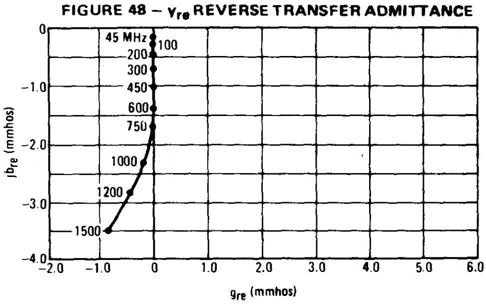


FIGURE 48 – y_{re} REVERSE TRANSFER ADMITTANCE



2N5031
2N5032

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

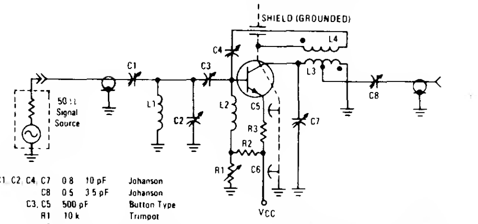
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	10	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)	I_{CBO}	—	1.0	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	h_{FE}	25	—	300	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	1000	—	3500	MHz
Collector-Base Capacitance (V_{CE} = 6.0 Vdc, I_E = 0, f = 0.1 MHz)	C_{cb}	—	1.3	1.5	pF
Collector Base Time Constant (I_C = 6.0 mAdc, V_{CE} = 6.0 Vdc, f = 31.8 MHz)	$rb'C_c$	—	5.0	—	ps
Noise Figure (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz) 2N5031 2N5032	NF	— —	— —	2.5 3.0	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc, f = 450 MHz)	G_{pe}	14	17	25	dB

FIGURE 1 – POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C1, C2, C4, C7	0.8 – 10 pF	Johanson
C8	0.5 – 3.5 pF	Johanson
C3, C5	500 pF	Button Type
R1	10 k	Trimpot
R2	2.7 k	1/4 watt 5%
R3	1.0 k	1/4 watt 5%

L1 1/4" Brass Rod, Solder Plated, 1 1/8" long Placed 5/8" from the socket and in parallel with the shield, which bisects the socket. The ungrounded side is soldered directly to the ungrounded side of C2

L2 0.22 μH

L3 1/4" Brass Rod, Solder Plated 1 1/2" long Placed 1/2" from the socket and in parallel with shield, which bisects the socket. The ungrounded side is soldered directly to the ungrounded side of C7. Output tap is 15/16" from ground

L4 1/2 Turn #16 5/16" above L3 and 5/8 long, (over L3)

FIGURE 2 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE

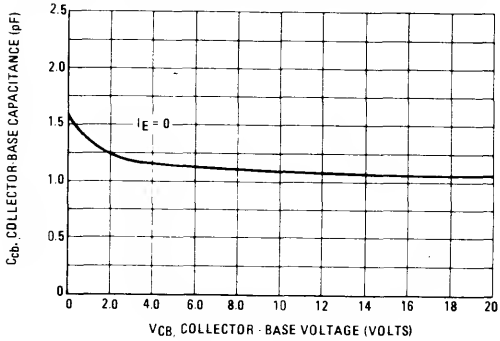


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

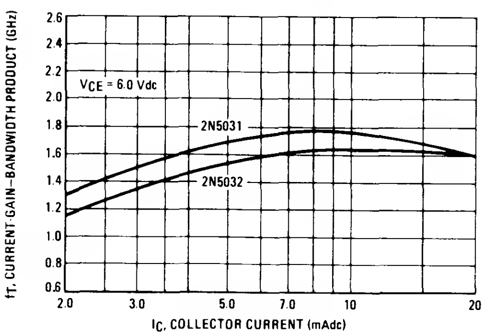


FIGURE 4 – S_{11} AND S_{22}

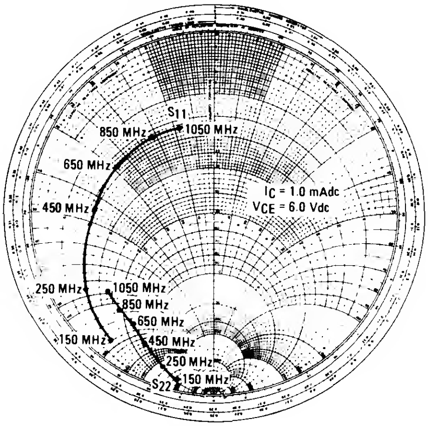


FIGURE 5 – S_{12}

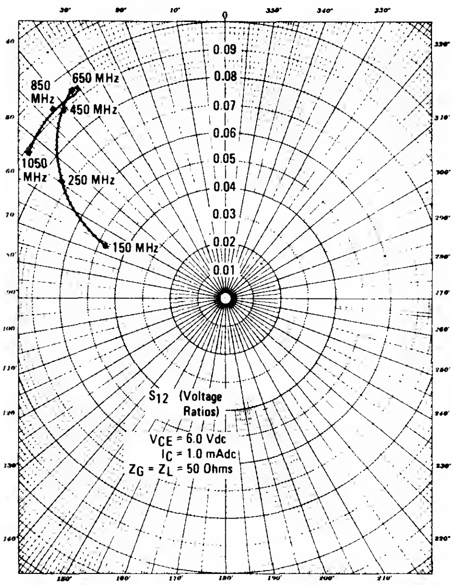


FIGURE 6 – S_{21}

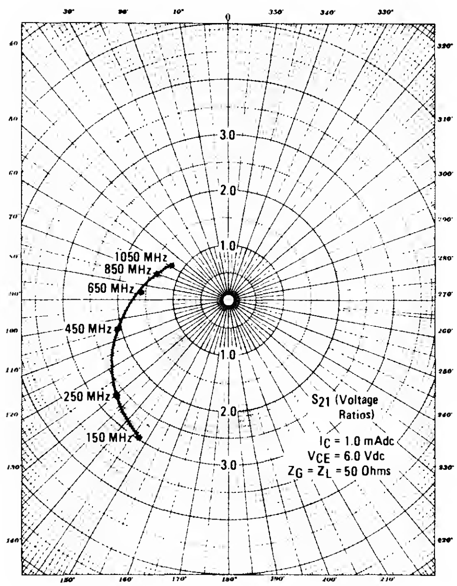


FIGURE 7 – NOISE FIGURE versus FREQUENCY

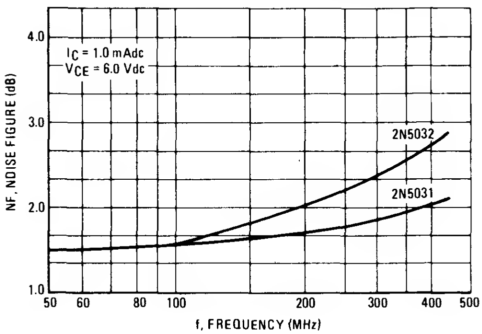


FIGURE 8 – POWER GAIN versus FREQUENCY

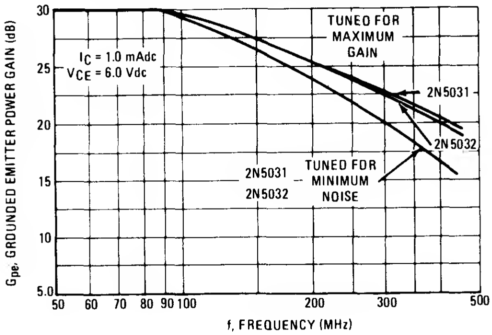


FIGURE 9 – INPUT ADMITTANCE versus FREQUENCY

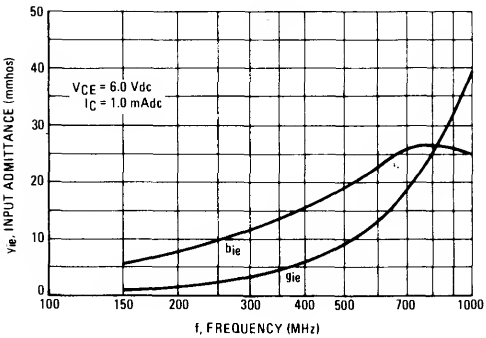


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

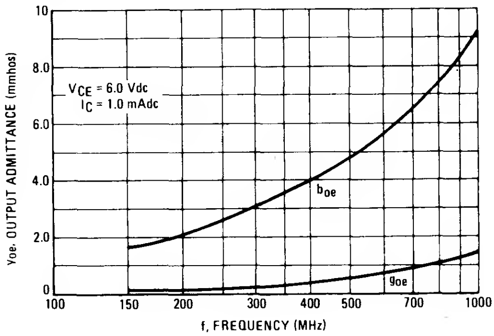


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FIGURE 11 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

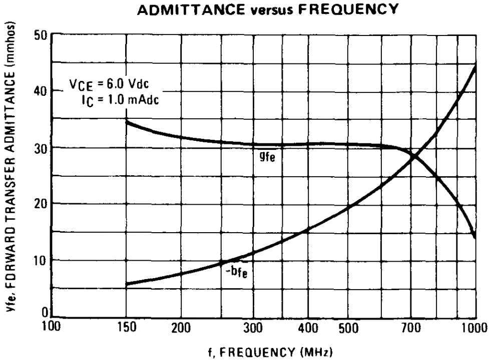
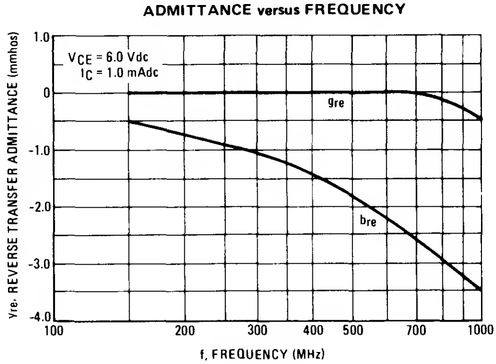


FIGURE 12 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



2N5108

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

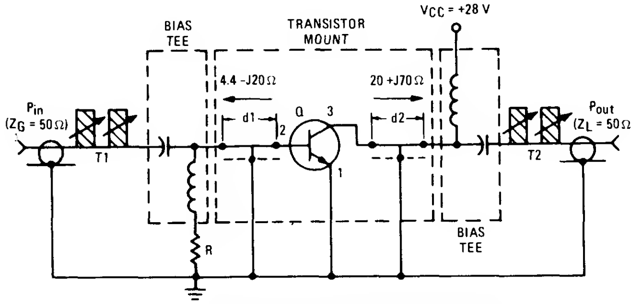
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Emitter Voltage (R_{BE} = 10Ω)	V_{CER}	55	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 0.02	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 10 ohms)	$V_{(BR)CER}$	55	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	55	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{BE} = 0) (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 150°C)	I_{CES}	 — —	 — —	 1.0 10	 μAdc mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	1200	—	—	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	1.3	3.0	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 1.0 W, V_{CC} = 28 Vdc, I_C = 102 mAdc, f = 1.0 GHz)	G_{PE}	5.0	—	—	dB
Power Output (Figure 1) (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 Ghz)	P_{out}	1.0	—	—	Watt
Collector Efficiency (Figure 1) (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	η	35	—	—	%
Power Output (Oscillator) (Figure 2) (V_{CE} = 20 Vdc, V_{EB} = 1.5 Vdc, f = 1.68 GHz) (Minimum Efficiency = 15%)	P_{out}	—	0.3	—	Watt

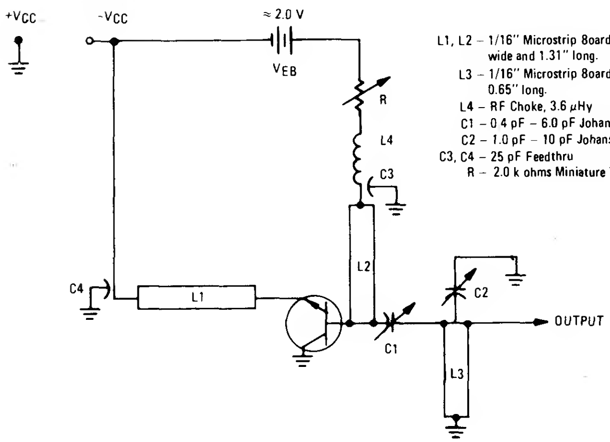
FIGURE 1 – 1 GHz RF AMPLIFIER OUTPUT POWER TEST CIRCUIT



d1: 1" Input line, center conductor width = 0.280"
d2: 1" Output line, center conductor width = 0 125"
Q: 2N5108
R: 3.9 ohms
T1, T2: Microlab Oouble Stub Tuner, or Equivalent
Bias Tee: Microlab 08N, or Equivalent
Transistor Mount: 1/32" Microstrip board

Note. Impedance measurements are made at transistor socket pins.

FIGURE 2 – 1.68 GHz RF OSCILLATOR OUTPUT POWER TEST CIRCUIT



L1, L2 – 1/16" Microstrip Board. Lines are 0.16" wide and 1.31" long.
L3 – 1/16" Microstrip Board. 0.16" wide and 0.65" long.
L4 – RF Choke, 3.6 μHy
C1 – 0 4 pF – 6.0 pF Johanson 4640
C2 – 1.0 pF – 10 pF Johanson 4355
C3, C4 – 25 pF Feedthru
R – 2.0 k ohms Miniature Trim pot

FIGURE 3 – OUTPUT POWER versus INPUT POWER

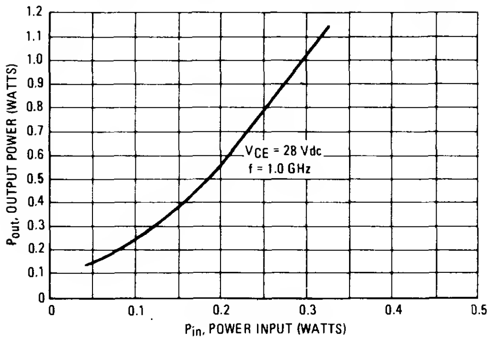


FIGURE 4 – OUTPUT POWER versus FREQUENCY

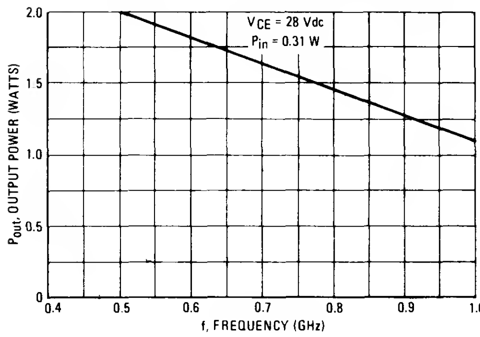


FIGURE 5 – OUTPUT POWER versus COLLECTOR-EMITTER VOLTAGE

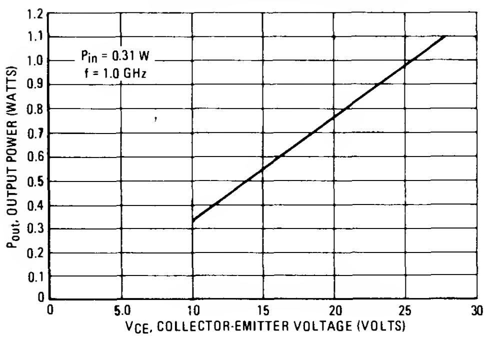


FIGURE 6 – OSCILLATOR OUTPUT POWER versus COLLECTOR CURRENT

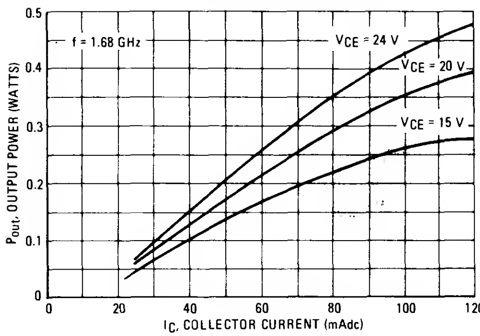


FIGURE 7 CURRENT-GAIN–BANDWIDTH PRODUCT versus CURRENT

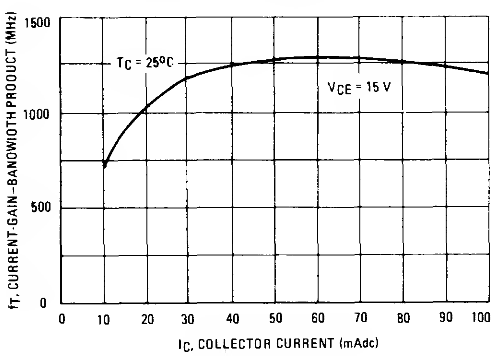
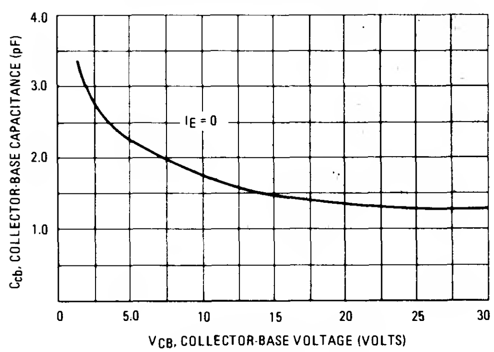


FIGURE 8 COLLECTOR BASE CAPACITANCE versus VOLTAGE



7

2N5109

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Base Current	I_B	400	mAdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_C = 75°C(1) Derate above 25°C	P_D	2.5 20	Watt mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

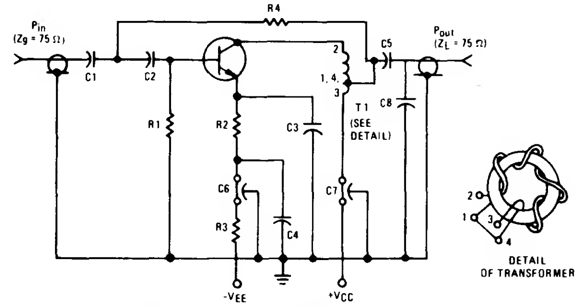
(1) Total Device Dissipation at T_A = 25°C is 1.0 Watt.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 5.0 mAdc, R_{BE} = 10 Ω)	$V_{(BR)CER}$	40	—	—	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = −1.5 V, T_C = 150°C) (V_{CE} = 35 Vdc, V_{BE} = −1.5 V)	I_{CEX}	 — —	 — —	 5.0 5.0	 mAdc mAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 360 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 15 Vdc)	h_{FE}	 5.0 40	 — —	 — 120	 — —
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	1200	—	—	MHz
Collector-Base Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	1.8	3.5	pF
Noise Figure (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	NF	—	3.0	—	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Voltage Gain (Figure 1) (I_C = 50 mAdc, V_{CC} = 15 Vdc, f = 50 to 216 MHz)	G_{ve}	11	—	—	dB
Power Input (Figure 2) (I_C = 50 mAdc, V_{CC} = 15 Vdc, R_S = 50 ohms, P_{out} = 1.26 mW, f = 200 MHz)	P_{in}	—	—	0.1	mW

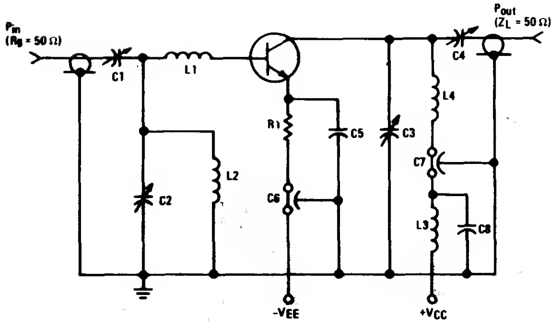
(2) Pulsed thru a 25 mH Inductor; 50% Duty Cycle.

FIGURE 1 – RF AMPLIFIER FOR VOLTAGE GAIN TEST CIRCUIT



C1, C2, C3, C5	0.002 µF	R3	330 Ω, 1 W
C4	0.03 µF	R4	200 Ω, 1/4 W
C6, C7	1500 pF	T1	4 Turns #30 Wire
C8	18 pF		Bifilar wound on "Indiana General"
R1	4.7 k, 1/4 W		Core #CF 102 Q1, or equivalent
R2	6.8 Ω, 1/2 W		

FIGURE 2 – 200 MHz TEST CIRCUIT



C1, C2, C3	1.0 – 30 pF	L1	4-1/2 turns, No. 22 wire, 3/16" I.D.
C4	1.0 – 20 pF	L4	3-1/2 turns, No. 22 wire, 3/16" I.D.
C5	10,000 pF	L2, L3	0.82 µH RFC
C6, C7	1,000 pF	R1	240 OHMS, 2 WATTS
C8	0.01 µF		

FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

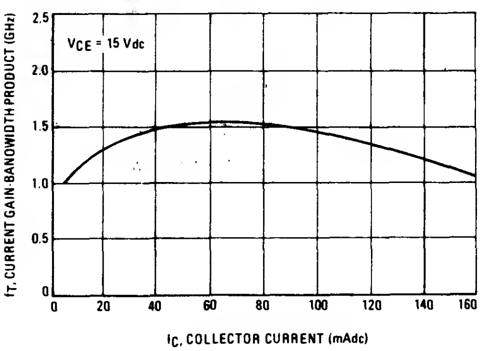


FIGURE 4 – COLLECTOR-BASE TIME CONSTANT

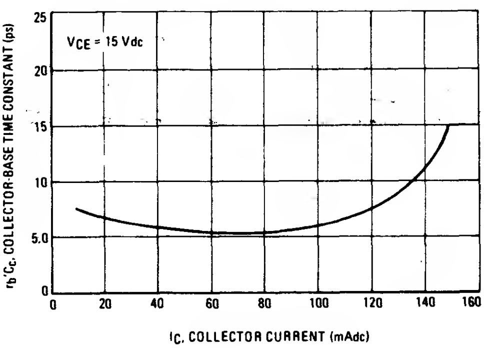


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FIGURE 5 – SATURATION VOLTAGES

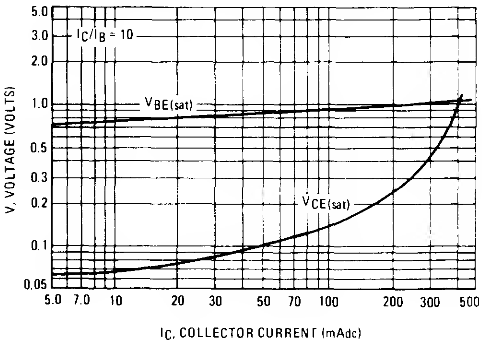

FIGURE 6 – CAPACITANCES versus REVERSE VOLTAGE

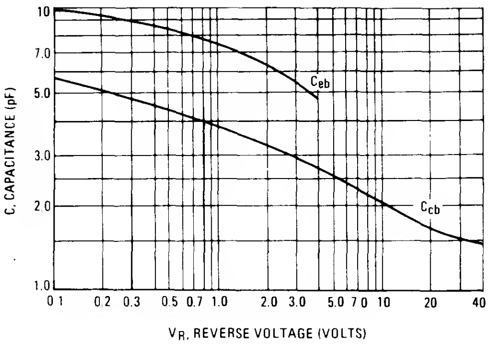

FIGURE 7 – INPUT ADMITTANCE versus FREQUENCY

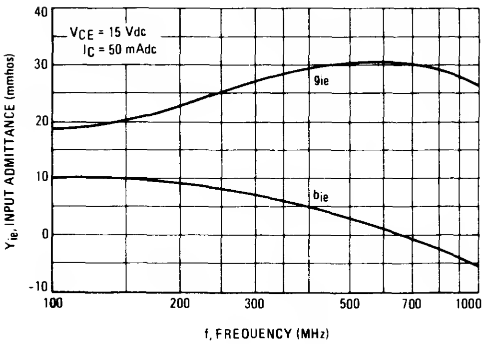

FIGURE 8 – INPUT ADMITTANCE versus COLLECTOR CURRENT

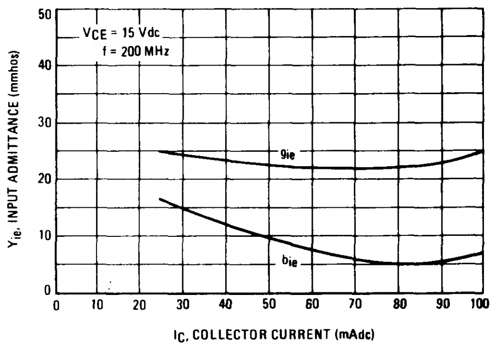

FIGURE 9 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

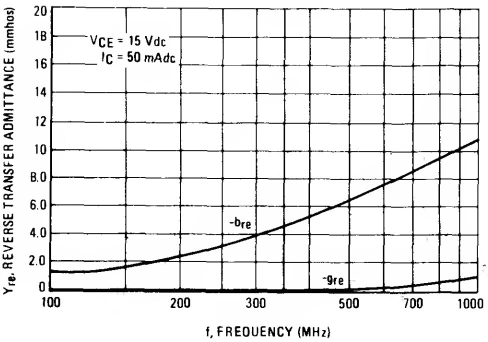

FIGURE 10 – REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT

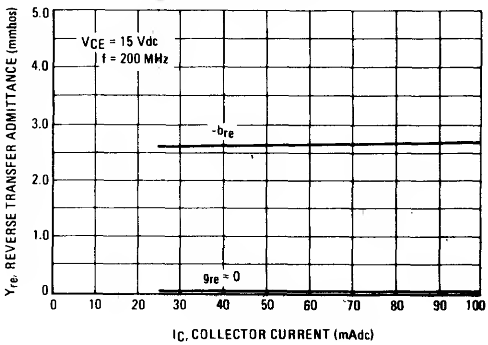

FIGURE 11 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

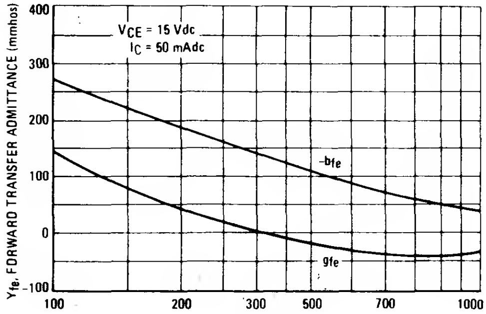

FIGURE 12 – FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

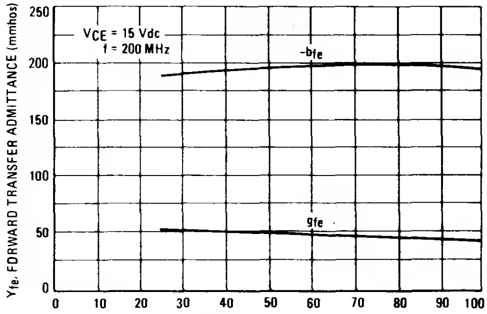

FIGURE 13 – OUTPUT ADMITTANCE versus FREQUENCY

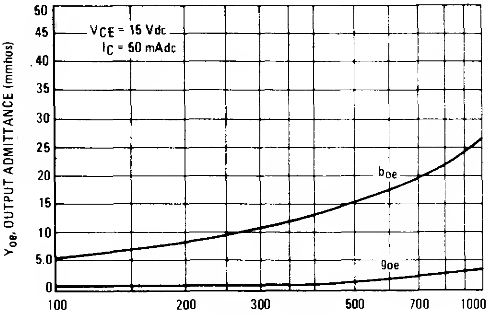

FIGURE 14 – OUTPUT ADMITTANCE versus COLLECTOR CURRENT

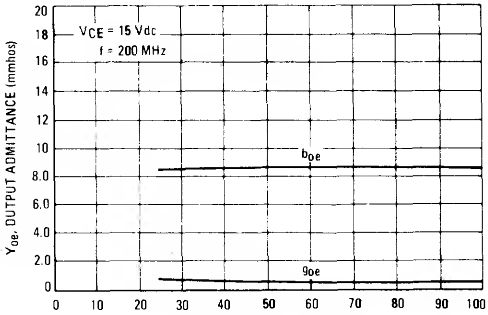

FIGURE 15 – INPUT REFLECTION COEFFICIENT versus FREQUENCY

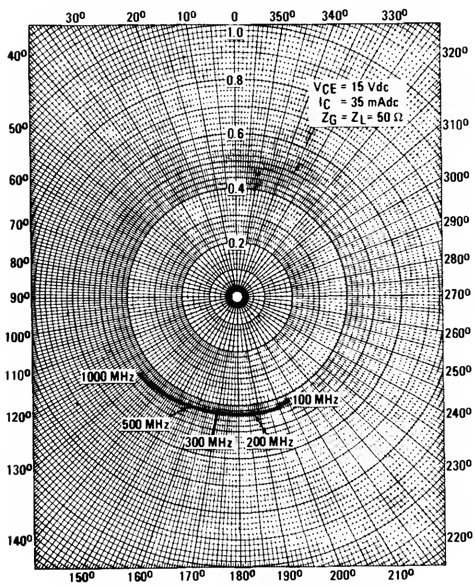

FIGURE 16 – OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

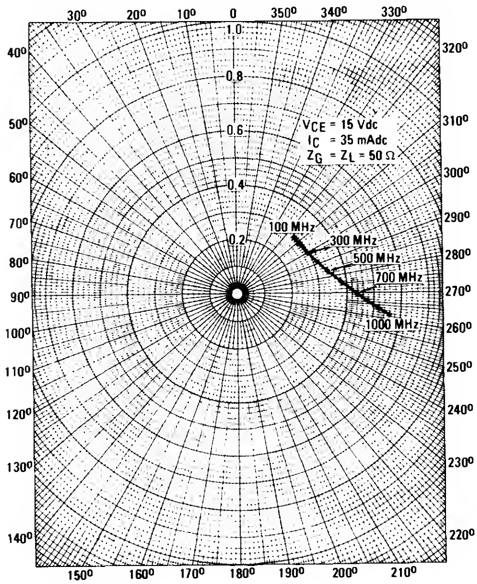

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FIGURE 17 – REVERSE TRANSMISSION COEFFICIENT versus FREQUENCY

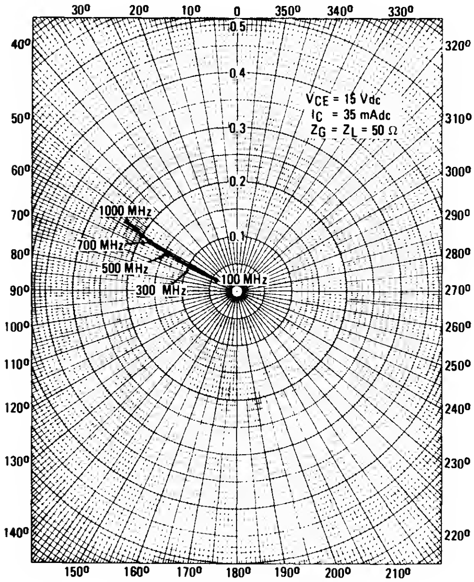


FIGURE 18 – FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY

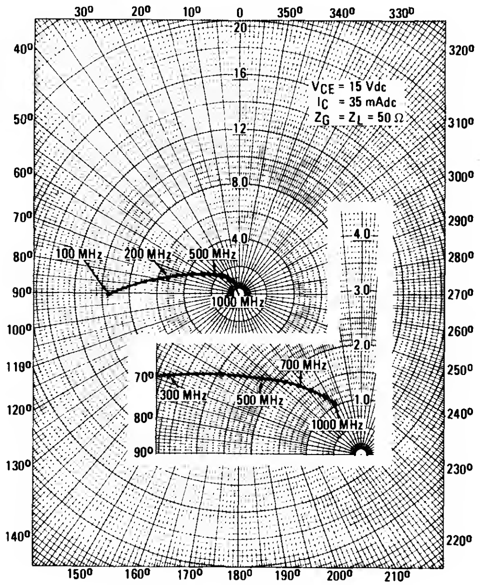
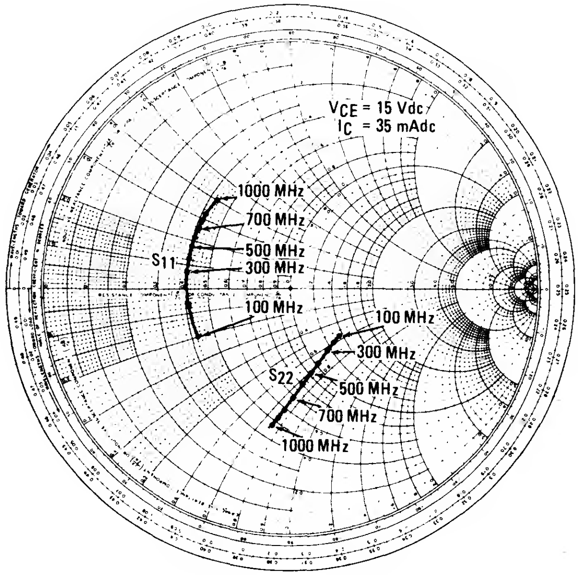


FIGURE 19 – INPUT REFLECTION COEFFICIENT AND OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



2N5160

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

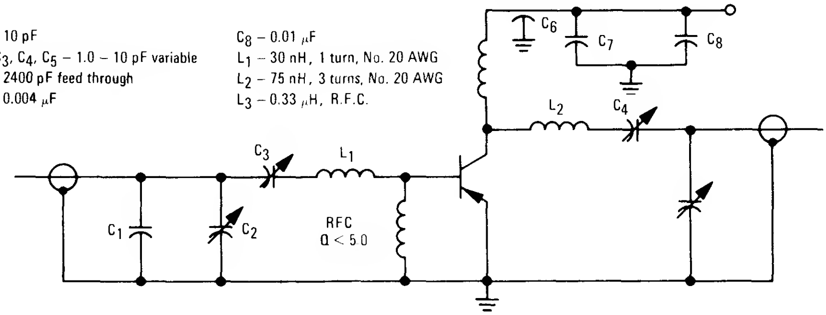
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0)	I_{CES}	—	—	0.1	mAdc
Collector Cutoff Current (V_{CB} = 28 Vdc, I_E = 0)	I_{CBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	900	—	MHz
Collector-Base Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	—	2.5	4.0	pF
FUNCTIONAL TEST					
Amplifier Power Gain (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz) (V_{CE} = 28 Vdc, P_{in} = 50 mW, f = 175 MHz)	G_{pe}	 8.0 —	 8.8 14.5	 — —	dB
Power Output (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz) (V_{CE} = 28 Vdc, P_{in} = 50 mW, f = 175 MHz)	P_{out}	 1.0 —	 1.2 1.4	 — —	Watt
Collector Efficiency (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz)	η	45	55	—	%

7

FIGURE 1 – 400-MHz TEST CIRCUIT

C_1 – 10 pF
C_2, C_3, C_4, C_5 – 1.0 – 10 pF variable
C_6 – 2400 pF feed through
C_7 – 0.004 μF
C_8 – 0.01 μF
L_1 – 30 nH, 1 turn, No. 20 AWG
L_2 – 75 nH, 3 turns, No. 20 AWG
L_3 – 0.33 μH, R.F.C.



POWER OUTPUT

FIGURE 2

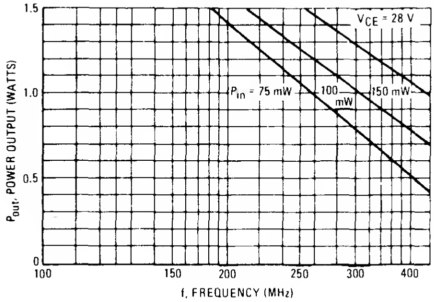
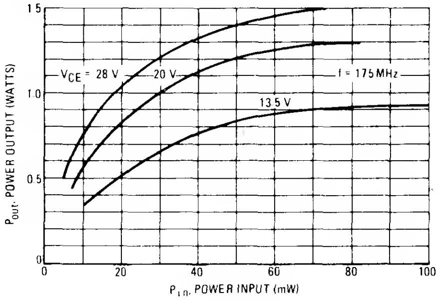


FIGURE 3



PARALLEL INPUT

FIGURE 4

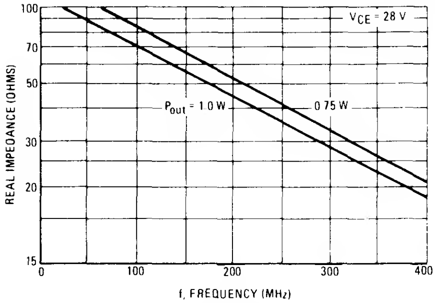


FIGURE 5

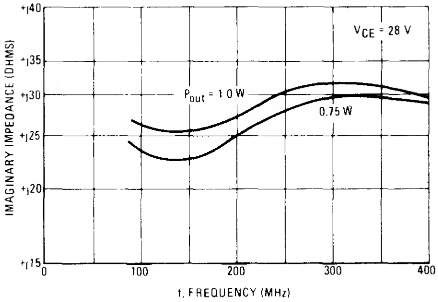


FIGURE 6 – PARALLEL OUTPUT CAPACITANCE versus FREQUENCY

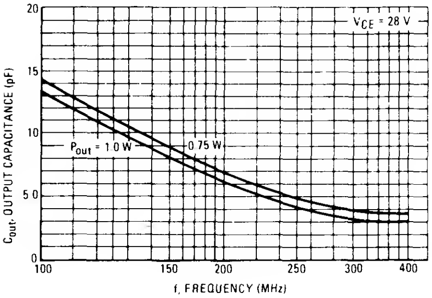
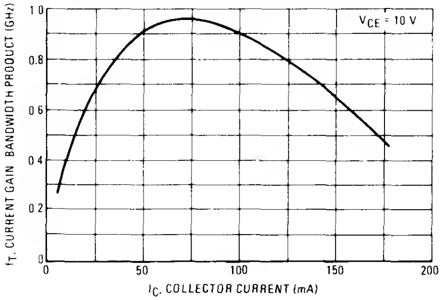


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT versus COLLECTOR CURRENT



2N5179

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage Applicable 1.0 to 2.0 mAdc	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

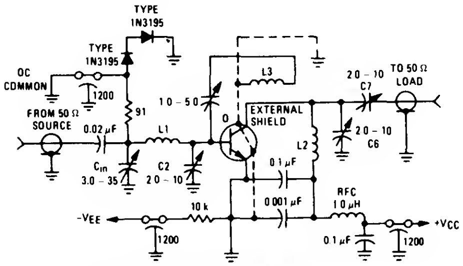
7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.001 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.02 1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	250	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	900	2000	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	—	1.0	pF
Small Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	25	300	—
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	$r_b'C_c$	3.0	14	ps
Noise Figure (Figure 1) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	—	4.5	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	G_{pe}	15	—	dB
Power Output (Figure 2) (V_{CB} = 10 Vdc, I_E = 12 mAdc, f≥500 MHz)	P_{out}	20	—	mW

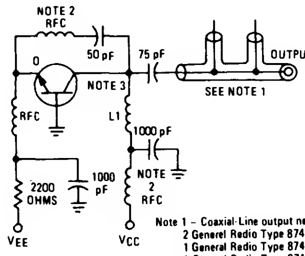
(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT



L1 1-3/4 Turns, #18 AWG, 0.5" L, 0.5" Diameter
L2 2 Turns, #16 AWG, 0.5" L, 0.5" Diameter
L3 2 Turns, #13 AWG, 0.25" L, 0.5" Diameter (Position 1/4" from L2)

FIGURE 2 – 500 MHz OSCILLATOR CIRCUIT



Note 1 – Coaxial-Line output network consisting of:
2 General Radio Type 874-TEE or equivalent
1 General Radio Type 874-D20 Adjustable Stub or equivalent
1 General Radio Type 874-LA Adjustable Line or equivalent
1 General Radio Type 874-WN3 Short-circuit termination or equivalent
Note 2 – RFC = 0.2 µH Ohmite #Z-460 or equivalent
Note 3 – Lead Number 4 (case) floating
L1 – 2 turns #16 AWG wire, 3/8 inch OD, 1 1/4 inch long
O = 2N5179

FIGURE 3 – NOISE FIGURE versus FREQUENCY

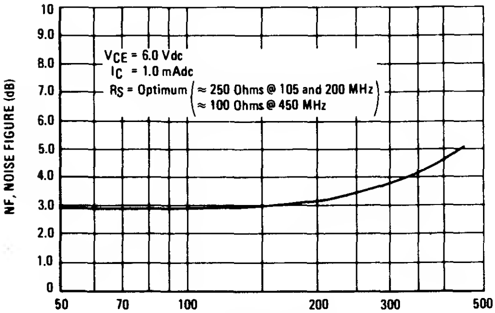


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

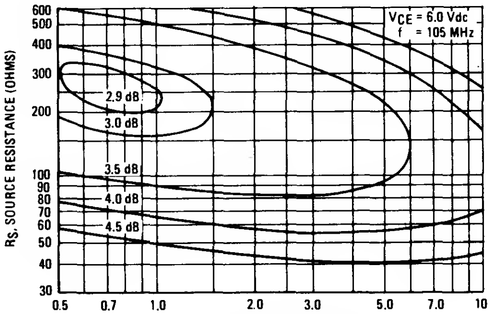


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

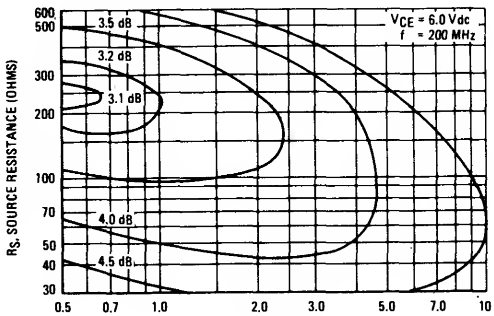


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT

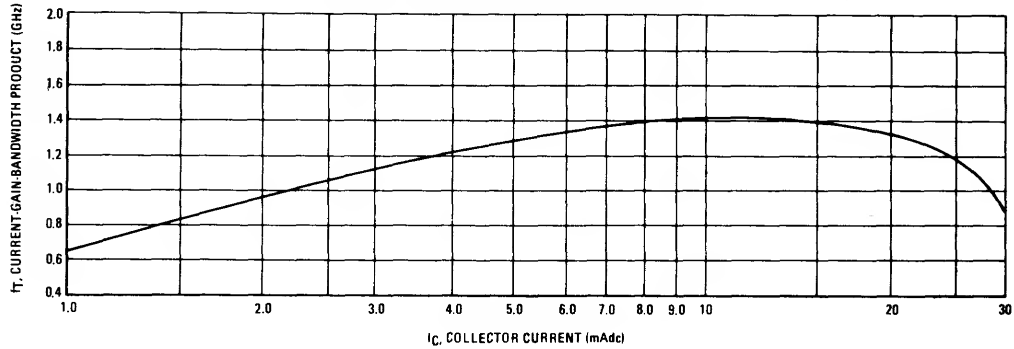


FIGURE 7 – INPUT ADMITTANCE versus FREQUENCY

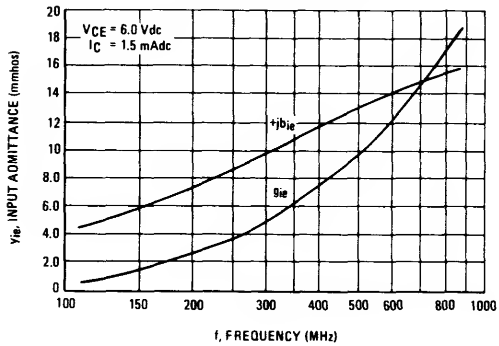


FIGURE 8 – OUTPUT ADMITTANCE versus FREQUENCY

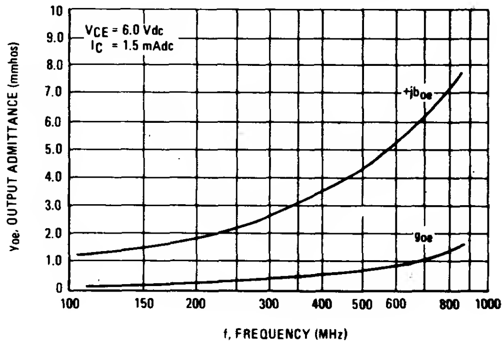


FIGURE 9 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

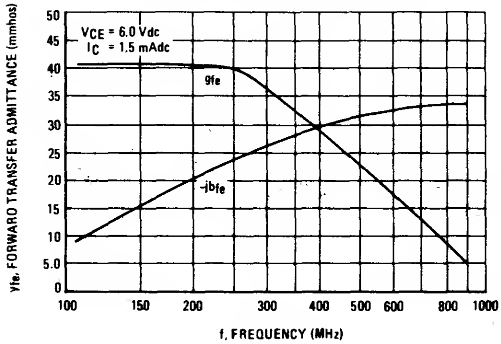


FIGURE 10 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

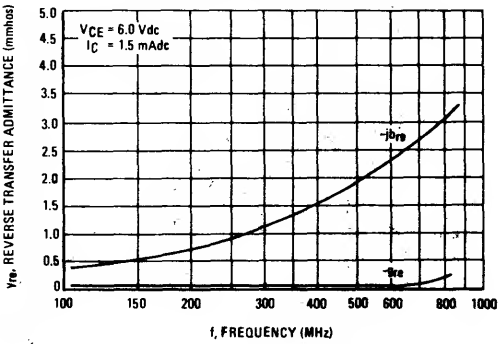


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FIGURE 11 — S_{11}, INPUT REFLECTION COEFFICIENT

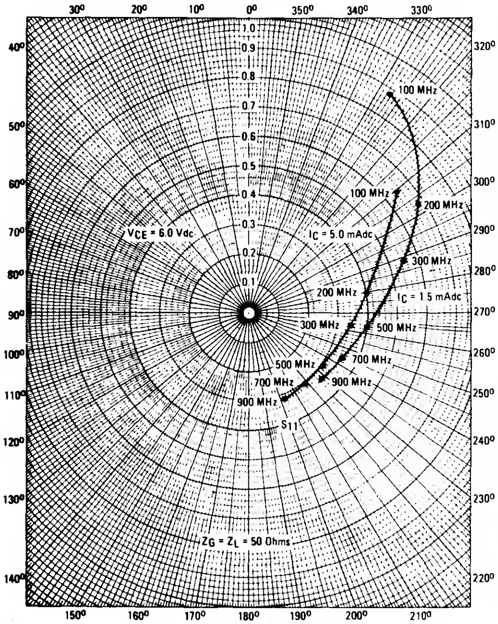


FIGURE 12 — S_{22}, OUTPUT REFLECTION COEFFICIENT

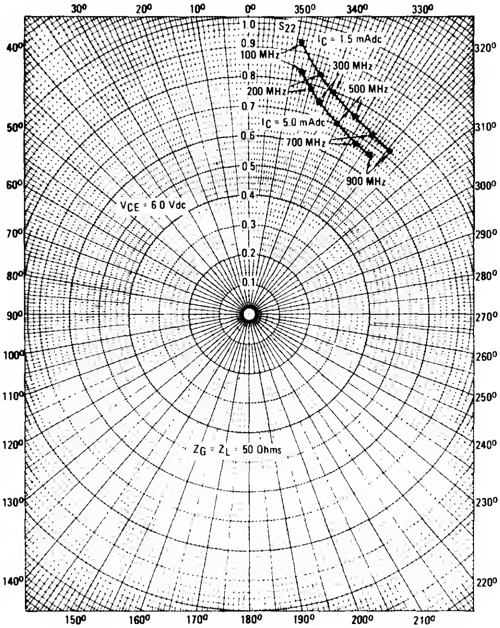


FIGURE 13 — S_{12}, REVERSE TRANSMISSION COEFFICIENT

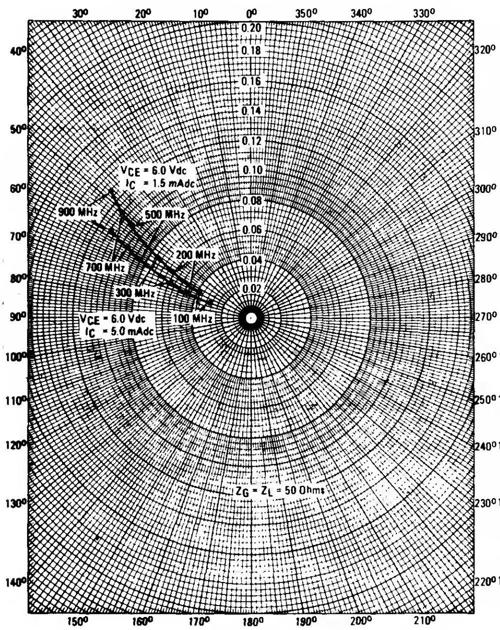


FIGURE 14 — S_{21}, FORWARD TRANSMISSION COEFFICIENT

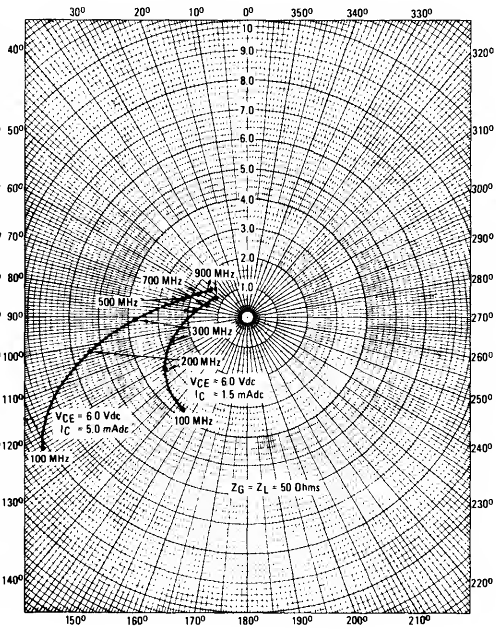
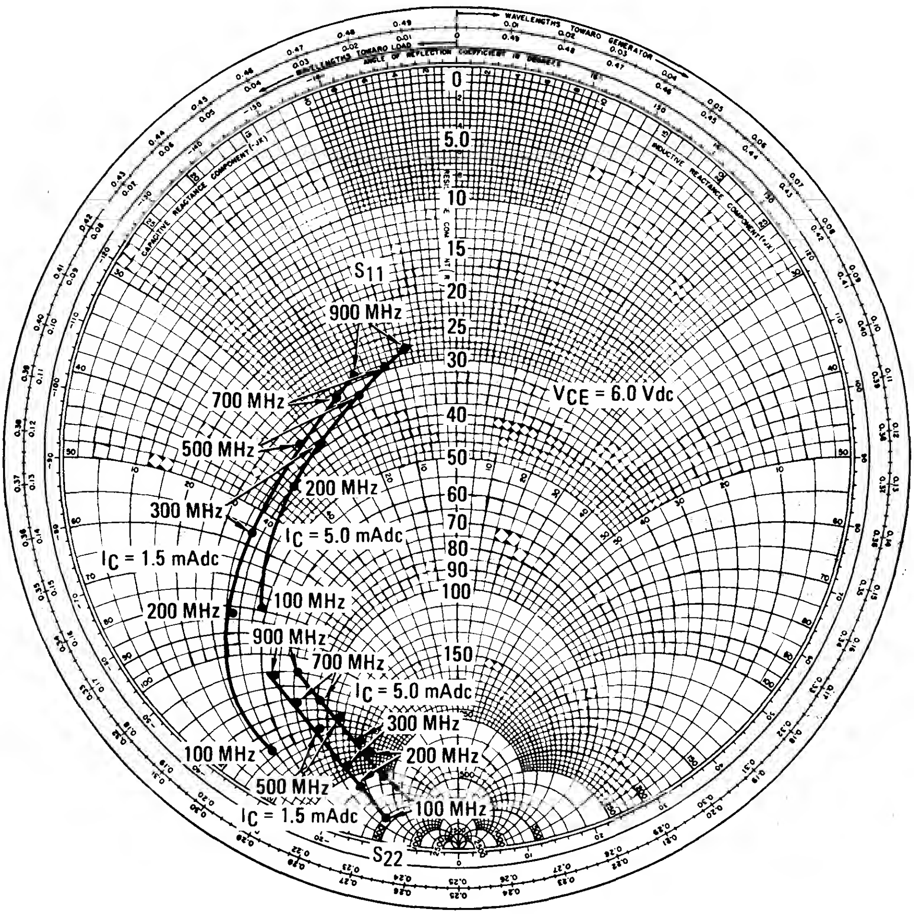


FIGURE 15 — S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



2N5583

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 40 mAdc, V_{CE} = 2.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc) (I_C = 300 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 20 25 15	 40 40 22	 — 100 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.6	0.8	Vdc
Base-Emitter On Voltage(1) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	—	0.84	1.8	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 40 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	 1000 1300	 1300 1500	 — —	MHz
Collector-Base Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	2.5	5.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	18	35	pF
Collector Base Time Constant (I_C = 50 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_{b'}C_C$	—	8.0	—	ps
SWITCHING CHARACTERISTICS (FIGURE 10)					
Turn-On Delay Time (V_{CC} = 31.4 Vdc, I_C = 150 mAdc, R_C = 160 Ohms, R_E = 26.6 Ohms)	t_d	—	1.0	—	ns
Rise Time	t_r	—	2.1	—	ns
Fall Time	t_f	—	1.8	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

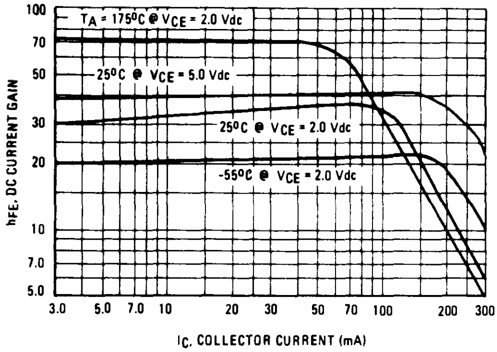


FIGURE 2 – COLLECTOR SATURATION REGION

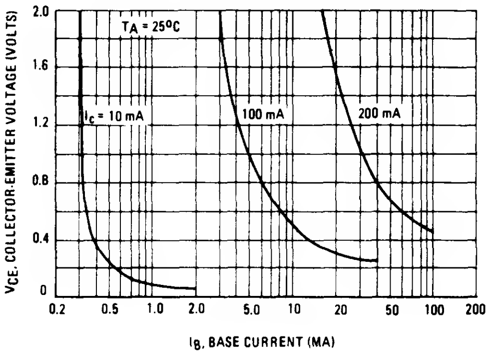


FIGURE 3 – "ON" VOLTAGES

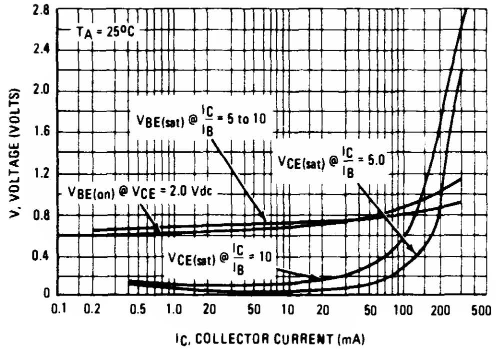


FIGURE 4 – COLLECTOR CURRENT versus BASE VOLTAGE

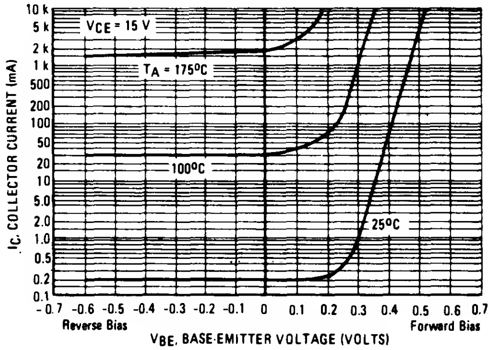


FIGURE 5 – CAPACITANCES

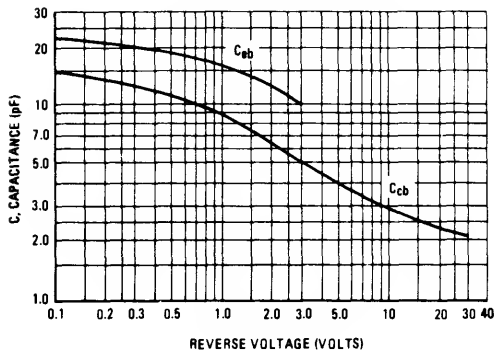


FIGURE 6 – TEMPERATURE COEFFICIENTS

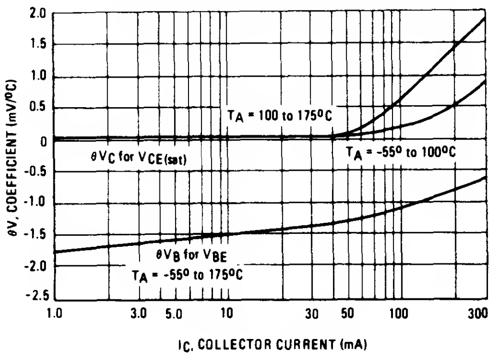


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FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

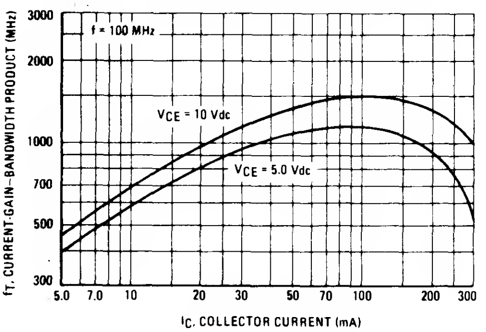


FIGURE 8 – COLLECTOR-BASE TIME CONSTANT

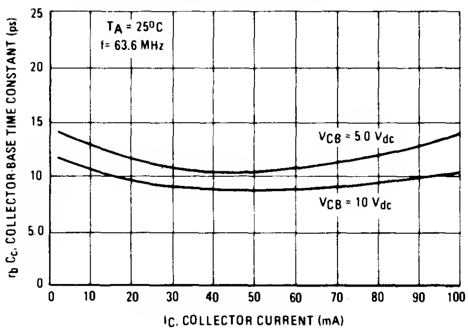


FIGURE 9 – SWITCHING TIMES

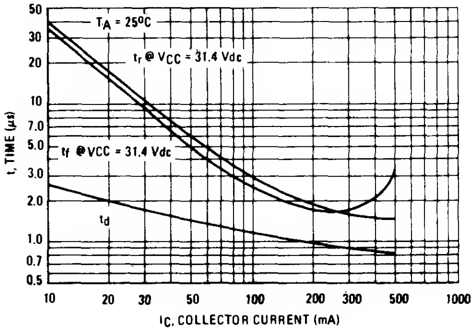
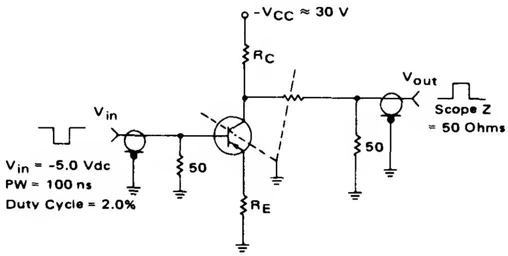


FIGURE 10 – SWITCHING TIMES TEST CIRCUIT



I_C mA	R_C Ohms	R_E Ohms	V_{CC} Volts
50	526	80	34.4
150	160	26.6	31.4
300	78	13.3	30.6
500	46.5	8.0	30.3

2N5829 For Specifications see 2N4957 Data.

2N5835
2N5836
2N5837

2N5835
CASE 20-03, STYLE 10
TO-72 (TO-206AF)

2N5836, 2N5837
CASE 26-03, STYLE 1
TO-46 (TO-206AB)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5835	2N5836	2N5837	Unit
Collector-Emitter Voltage	V_{CEO}	10	10	5.0	Vdc
Collector-Base Voltage	V_{CBO}	15	15	10	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	3.5	3.5	Vdc
Collector Current — Continuous	I_C	15	200	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 200 1.14	 — —	 — —	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 — —	 2.0 11.43	 2.0 11.43	 Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

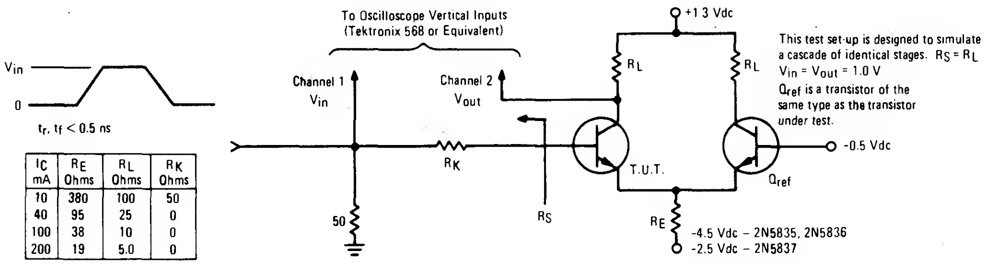
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0) (I_C = 100 μAdc, I_E = 0)	 2N5835 2N5836 2N5837	$V_{(BR)CBO}$	 15 15 10	 — — —	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 7.5 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 5.0 Vdc, I_E = 0)	 2N5835 2N5836 2N5837	I_{CBO}	 — — —	 — — —	 0.01 10 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 6.0 Vdc) (I_C = 50 mAdc, V_{CE} = 6.0 Vdc) (I_C = 100 mAdc, V_{CE} = 3.0 Vdc)	 2N5835 2N5836 2N5837	h_{FE}	 25 25 25	 — — —	 — — —	—
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 6.0 Vdc) (I_C = 50 mAdc, V_{CE} = 6.0 Vdc) (I_C = 100 mAdc, V_{CE} = 3.0 Vdc)	 2N5835 2N5836 2N5837	$V_{BE(on)}$	 — — —	 — — —	 0.9 0.9 0.9	Vdc
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz) (I_C = 50 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz) (I_C = 100 mAdc, V_{CE} = 3.0 Vdc, f = 200 MHz)	 2N5835 2N5836 2N5837	f_T	 2.5 2.0 1.7	 — — —	 — — —	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz) (V_{CB} = 5.0 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	 2N5835 2N5836 2N5837	C_{cb}	 — — —	 — — —	 0.8 3.5 5.0	pF
Collector Base Time Constant(2) (I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 63.6 MHz) (I_C = 50 mAdc, V_{CE} = 6.0 Vdc, f = 63.6 MHz) (I_C = 100 mAdc, V_{CE} = 3.0 Vdc, f = 63.6 MHz)	 2N5835 2N5836 2N5837	$r_b'C_c$	 — — —	 5.0 6.0 6.0	 — — —	ps

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS(2)						
Rise Time (Figure 1)		t_r				ns
(I_C = 10 mAdc)	2N5835		—	250	—	
(I_C = 40 mAdc)	2N5836		—	320	—	
(I_C = 100 mAdc)	2N5837		—	650	—	

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(2) Typical values shown in addition to JEDEC Registered Data.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



IC mA	RE Ohms	RL Ohms	RK Ohms
10	380	100	50
40	95	25	0
100	38	10	0
200	19	5.0	0

FIGURE 2 – SWITCHING TIME

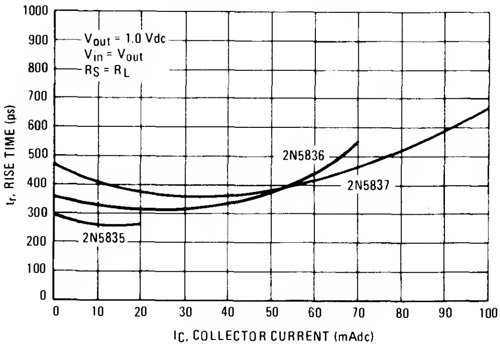


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

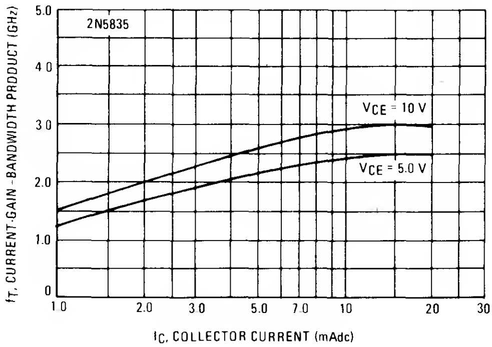


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

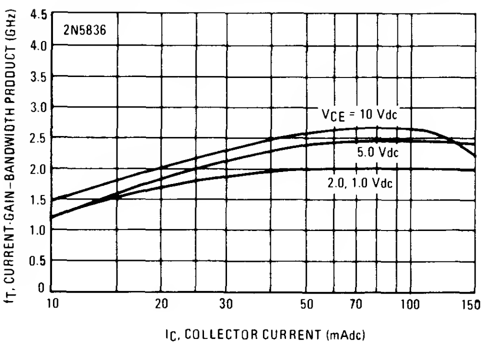


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

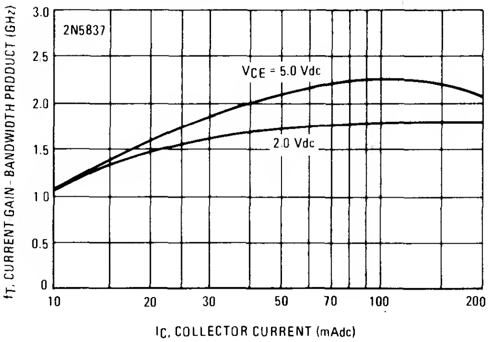


FIGURE 6 – COLLECTOR-BASE TIME CONSTANT

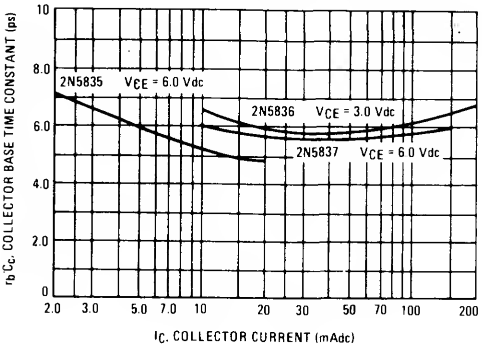
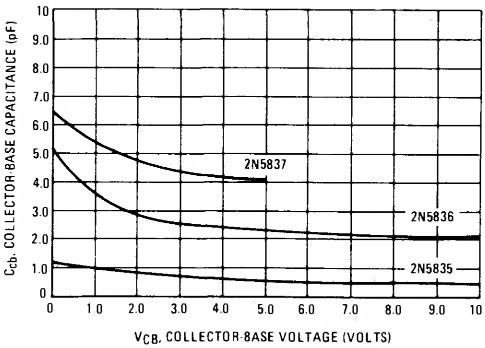


FIGURE 7 – COLLECTOR-BASE CAPACITANCE



2N5835 SCATTERING PARAMETERS

(I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, Z_G = Z_L = 50 Ohms)

FIGURE 8 – S_{11}, INPUT REFLECTION COEFFICIENT

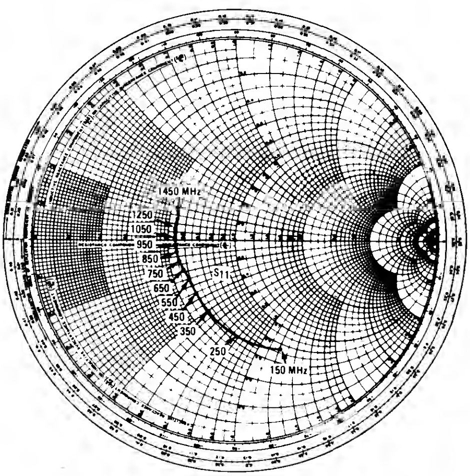


FIGURE 9 – S_{22}, OUTPUT REFLECTION COEFFICIENT

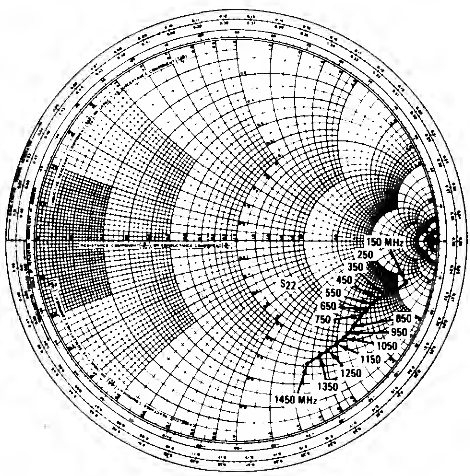


FIGURE 10 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

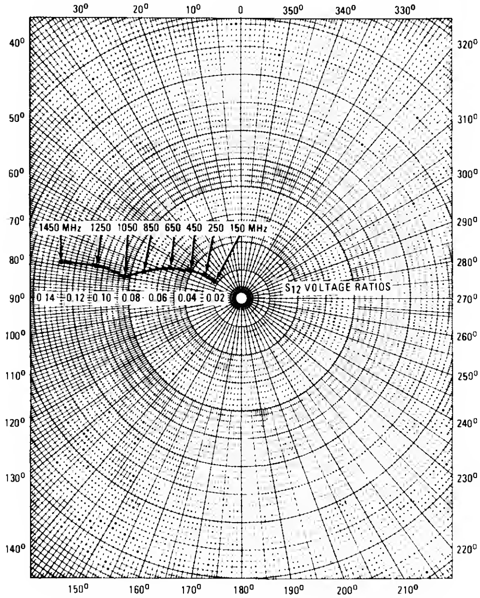
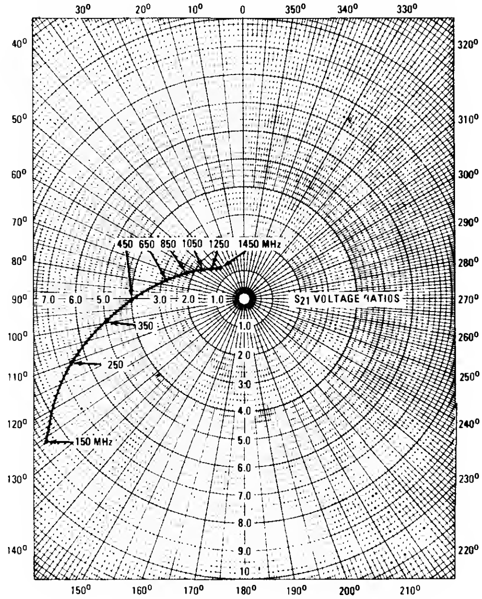


FIGURE 11 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



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2N5836 SCATTERING PARAMETERS

(I_C = 100 mAdc, V_{CE} = 10 Vdc, Z_G = Z_L = 50 Ohms)

FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

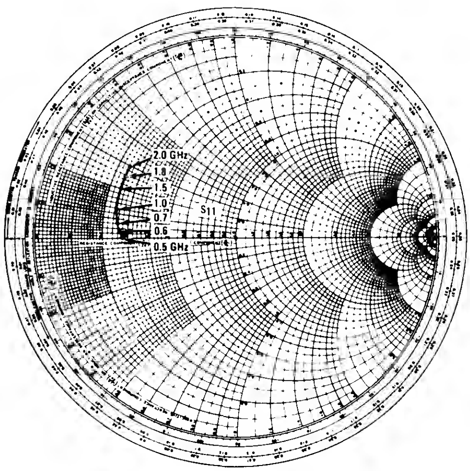


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

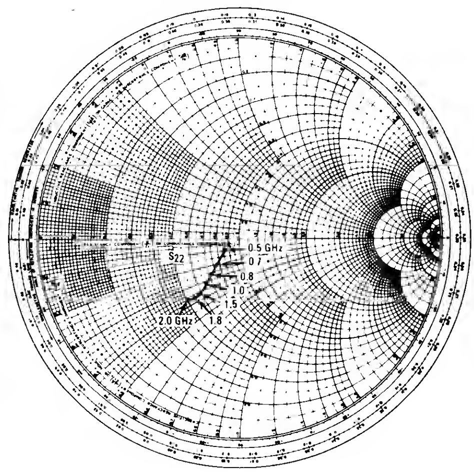


FIGURE 14 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

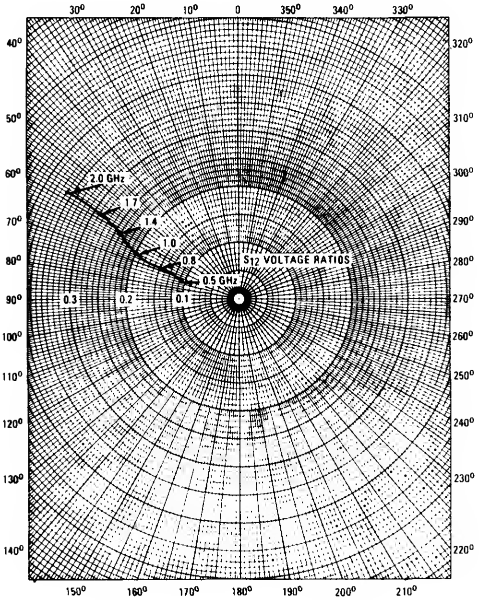
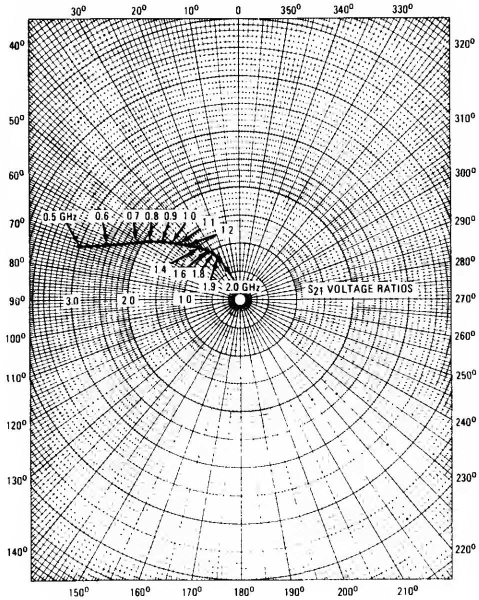


FIGURE 15 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



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2N5837 SCATTERING PARAMETERS

(I_C = 100 mAdc, V_{CE} = 3.0 Vdc, Z_G = Z_L = 50 Ohms)

FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT

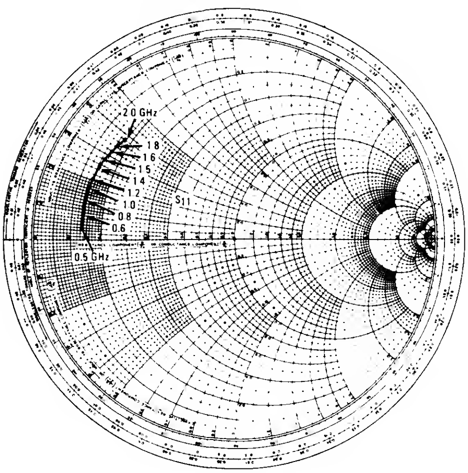


FIGURE 17 – S_{22}, OUTPUT REFLECTION COEFFICIENT

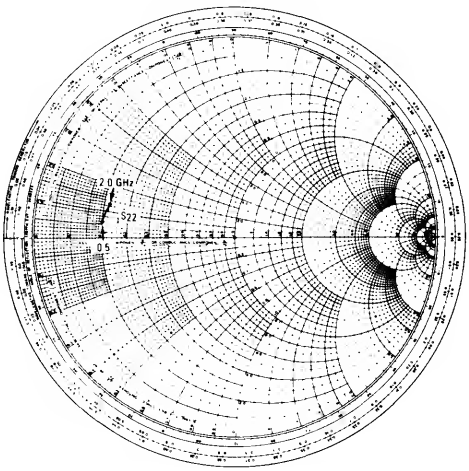


FIGURE 18 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

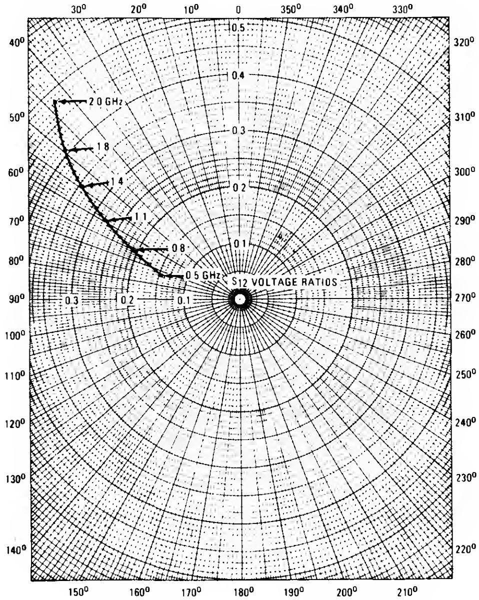
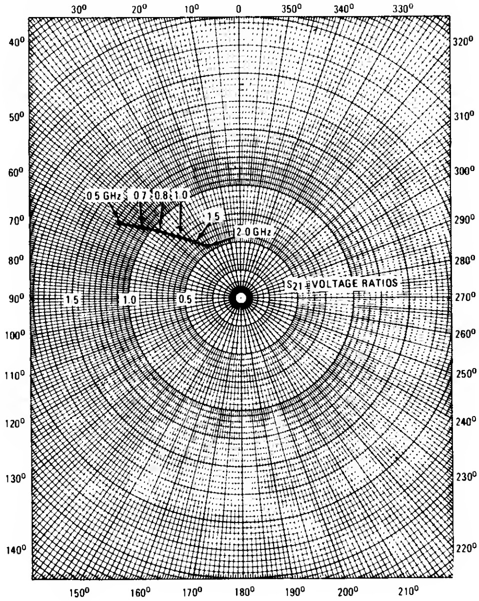


FIGURE 19 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



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2N5943

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 0.02	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	—	—	50	μAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)	h_{FE}	25	—	300	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.15	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	—	0.88	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	 1000 1200 1000	 1350 1550 1425	 — 2400 —	MHz
Collector-Base Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	1.0	1.6	2.5	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	8.4	15	pF
Small Signal Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 1.0 kHz)	h_{fe}	25	—	350	—
Collector Base Time Constant (I_E = 50 mAdc, V_{CB} = 15 Vdc, f = 31.8 MHz)	$r_b'C_c$	2.0	5.5	20	ps
Noise Figure (I_C = 30 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (Figure 1) (I_C = 35 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (Figure 6)	NF	 — —	 3.4 6.8	 — 8.0	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (Figure 1) (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 250 MHz) (Figure 6)	G_{pe}	 — 7.0	 11.4 7.6	 — —	dB
Intermodulation Distortion (I_C = 50 mAdc, V_{CE} = 15 Vdc, V_{out} = +50 dBmV)	IM	—	—	−50	dB
Cross Modulation Distortion (I_C = 50 mAdc, V_{CE} = 15 Vdc, V_{out} = +40 dBmV) (I_C = 50 mAdc, V_{CE} = 15 Vdc, V_{out} = +50 dBmV)	XM	 — —	 −67 −45	 — −42	dB

7

FIGURE 1 – NARROW-BAND TEST CIRCUIT

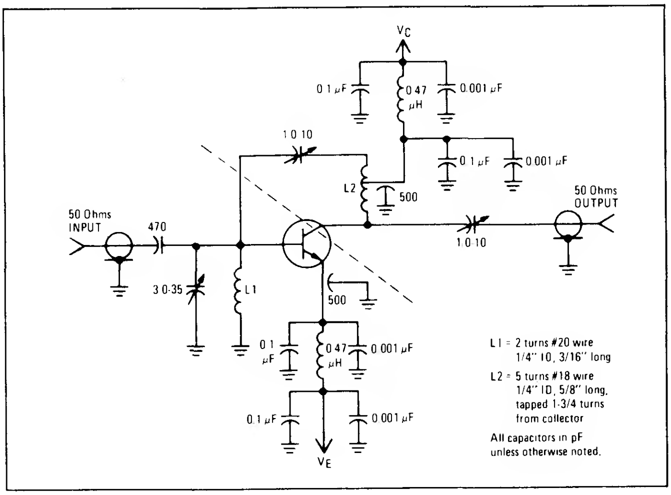


FIGURE 2 – CURRENT-GAIN – BANDWIDTH PRODUCT

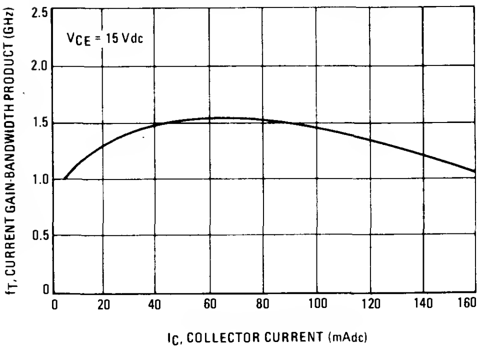


FIGURE 3 – COLLECTOR-BASE TIME CONSTANT

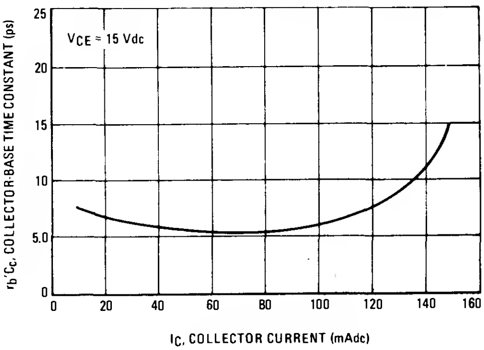


FIGURE 4 – SATURATION VOLTAGES

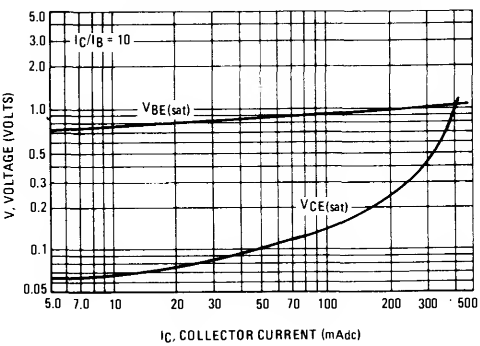


FIGURE 5 – CAPACITANCES versus REVERSE VOLTAGE

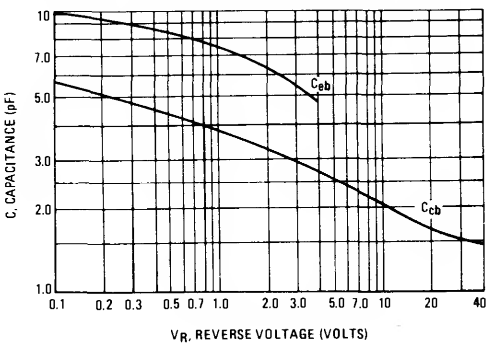
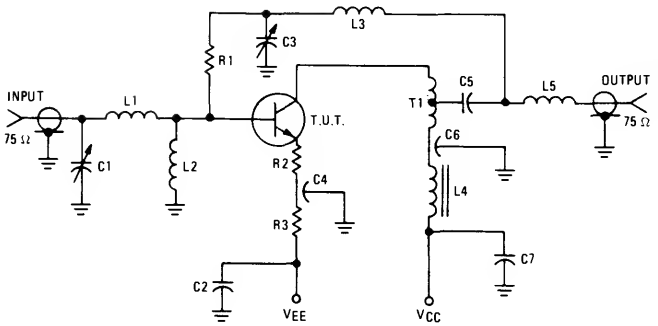


FIGURE 6 – BROADBAND TEST CIRCUIT



C1	1.0-10 pF	JOHANSON 2951 OR EQUIVALENT
C2, C7	0.01 μF	
C3	0.5-6.0 pF	JOHANSON 4642 OR EQUIVALENT
C4, C6	1500 pF	
C5	470 pF	
L1	2 TURNS AWG #26, 5/32" I.D.	
L2	1 μH MOLDED CHOKE	
L3	5 TURNS AWG #26, 3/32" I.D.	
L4	FERRITE CHOKE, 3 TURNS #30 ON STACKPOLE 57-0156 BEAD	
L5	2 TURNS AWG #26, 3/32" I.D.	
T1	AWG #30 TRIFILAR WOUND 1-9-9 ON STACKPOLE 57-0985, #11 TOROID	
R1	270 OHMS	
R2	18 OHMS	
R3	150 OHMS	

GARLOCK TEFLON SOCKET

FIGURE 7 – CROSS-MODULATION DISTORTION versus COLLECTOR CURRENT

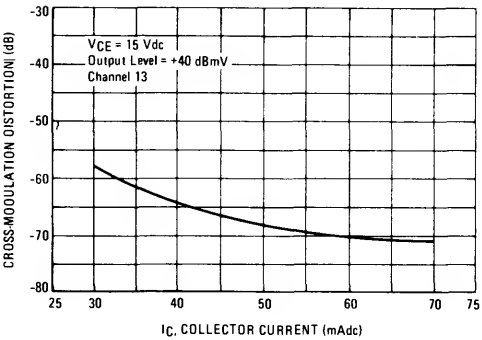


FIGURE 8 – CROSS-MODULATION DISTORTION versus OUTPUT LEVEL

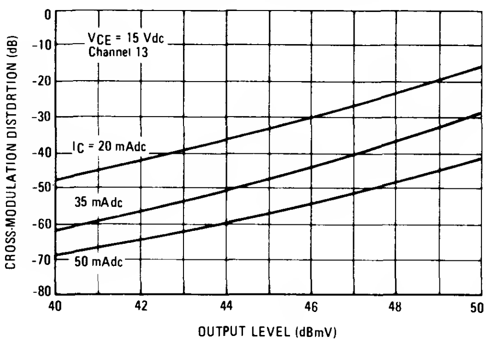


FIGURE 9 – NARROWBAND NOISE FIGURE versus COLLECTOR CURRENT

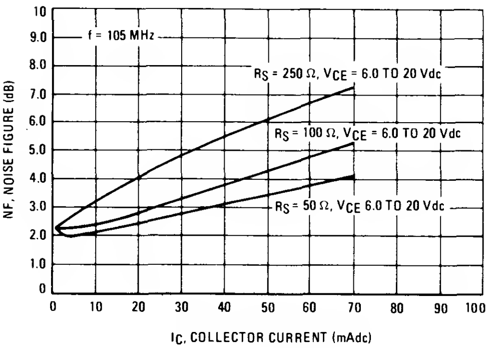


FIGURE 10 – NARROWBAND NOISE FIGURE versus COLLECTOR CURRENT

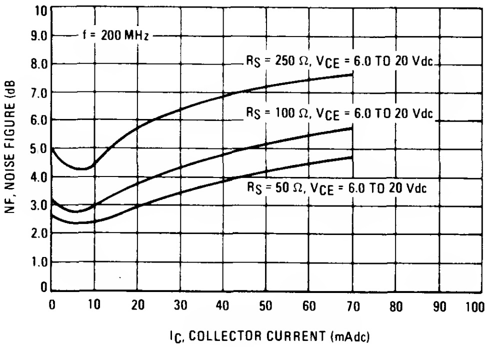


FIGURE 11 – BROADBAND NOISE FIGURE versus COLLECTOR CURRENT

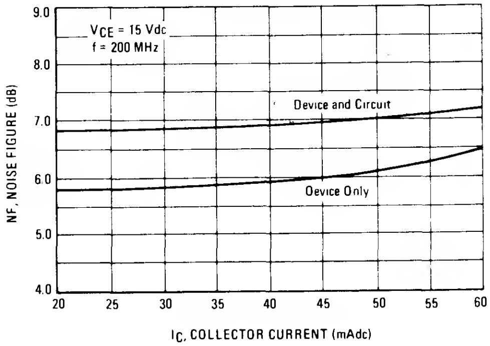


FIGURE 12 – NARROWBAND NOISE FIGURE versus FREQUENCY

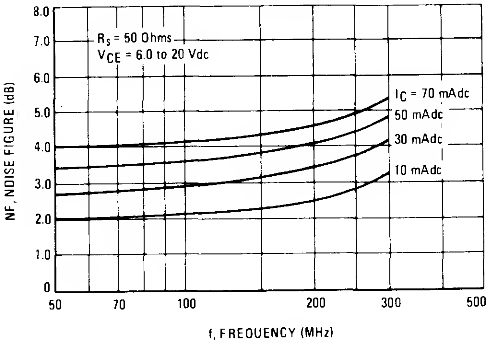


FIGURE 13 – INPUT ADMITTANCE versus FREQUENCY

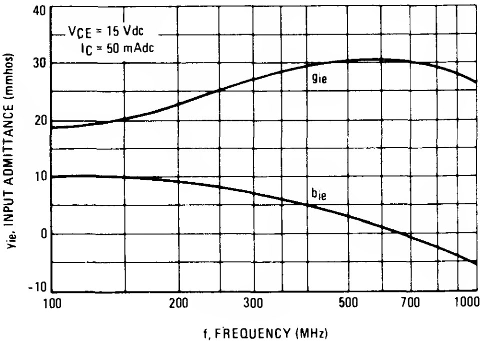


FIGURE 14 – INPUT ADMITTANCE versus COLLECTOR CURRENT

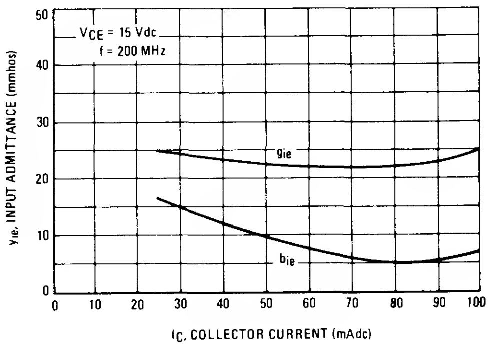


FIGURE 15 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

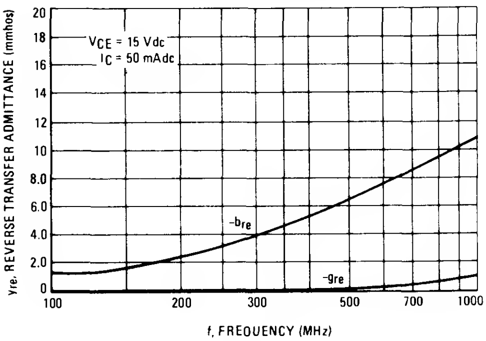


FIGURE 16 – REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT

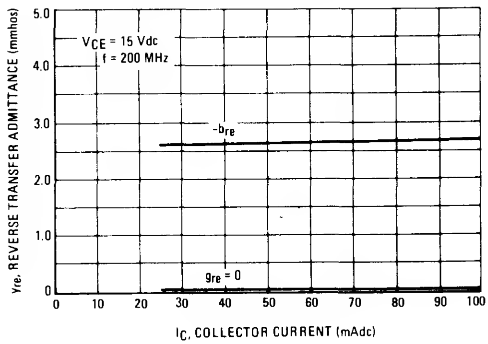


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FIGURE 17 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

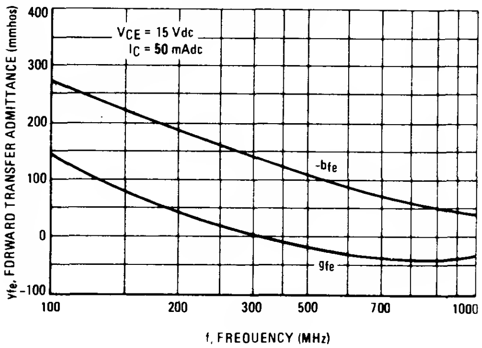


FIGURE 18 – FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

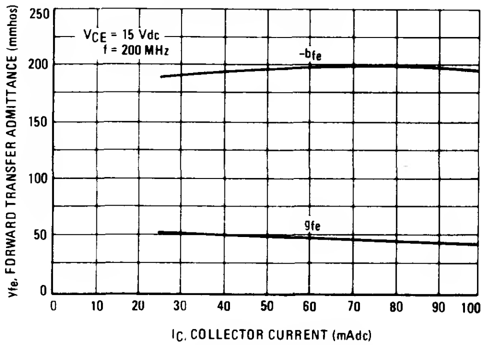


FIGURE 19 – OUTPUT ADMITTANCE versus FREQUENCY

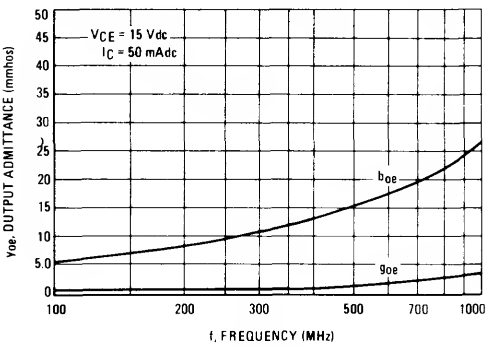


FIGURE 20 – OUTPUT ADMITTANCE versus COLLECTOR CURRENT

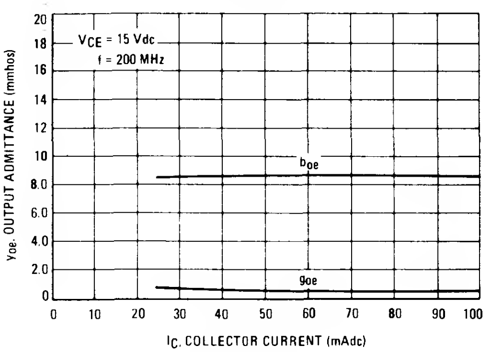


FIGURE 21 – INPUT REFLECTION COEFFICIENT versus FREQUENCY

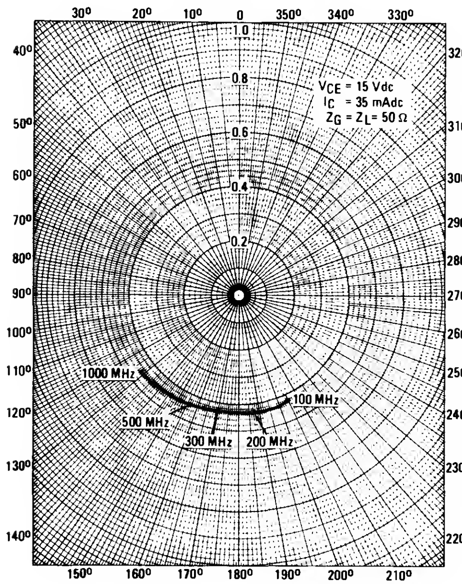
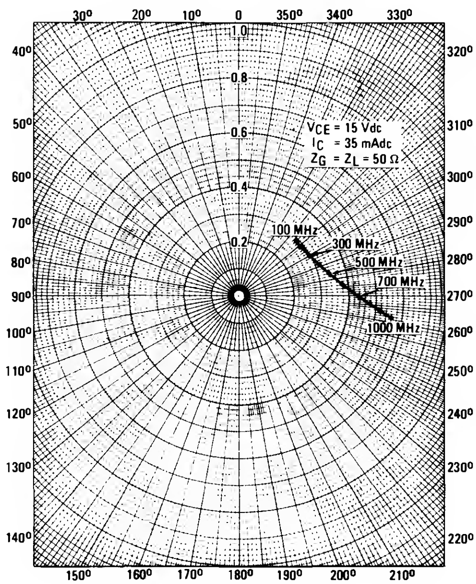


FIGURE 22 – OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



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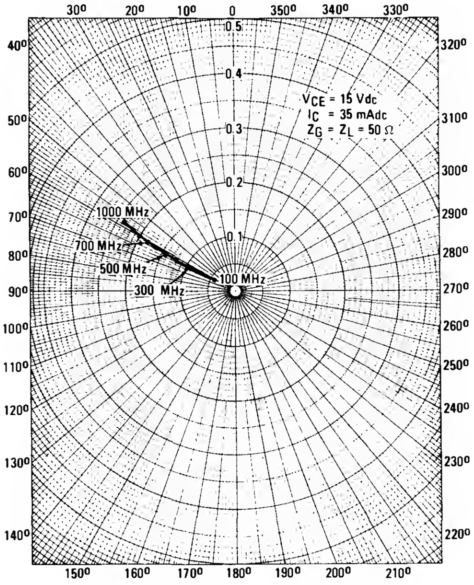


FIGURE 23 – REVERSE TRANSMISSION COEFFICIENT versus FREQUENCY

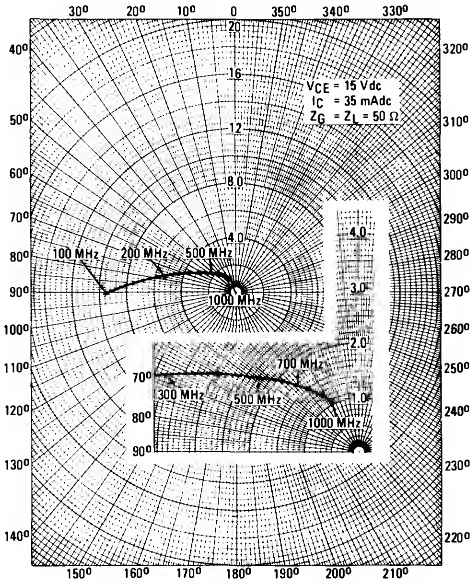


FIGURE 24 – FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY

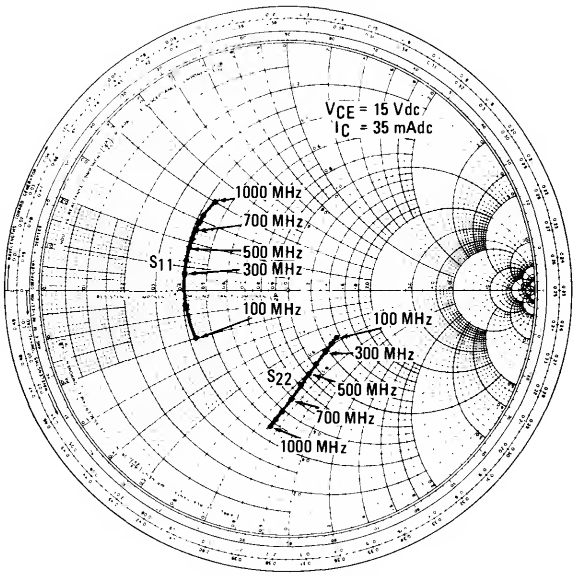


FIGURE 25 – INPUT REFLECTION COEFFICIENT AND OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

2N5947

CASE 244A-01, STYLE 1
TO-117 (TO-232AA)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

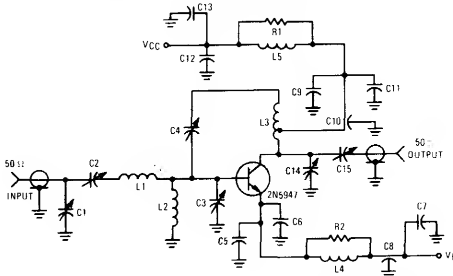
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	—	—	100	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)	I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 75 mAdc, V_{CE} = 20 Vdc)	h_{FE}	25	—	250	—
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	—	0.2	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc)	$V_{BE(sat)}$	—	1.0	1.5	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 75 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	1100	1500	—	MHz
Collector-Base Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	1.5	4.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	8.2	12	pF
Small Signal Current Gain (I_C = 75 mAdc, V_{CE} = 20 Vdc, f = 1.0 kHz)	h_{fe}	25	—	300	—
Collector Base Time Constant (I_E = 75 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	$r_b'C_c$	2.0	—	20	ps
Noise Figure (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz) (Figure 1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)(1) (Figure 2) (I_C = 75 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)(1) (Figure 2)	NF	 — — —	 3.8 7.2 7.8	 — 8.5 —	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 2) (I_C = 75 mAdc, V_{CE} = 20 Vdc, f = 250 MHz)	G_{pe}	10	11	—	dB
Intermodulation Distortion (Figure 2) (I_C = 75 mAdc, V_{CE} = 20 Vdc, V_{out} = +50 dBmV)	IM	—	−55	−50	dB
Cross Modulation Distortion (Figure 2) (I_C = 75 mAdc, V_{CE} = 20 Vdc, V_{out} = +50 dBmV)	XM	—	−60	−57	dB

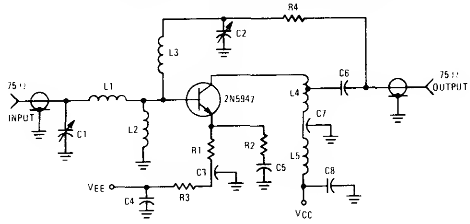
(1) Includes noise figure of post-amplifier and matching pad.

FIGURE 1 – NARROWBAND TEST CIRCUIT



C1 C2, C3	1 0 20 pF		
C4, C14 C15	1 0 - 10 pF	L2	1 1/2 Turns AWG #18 1/4" I D, 3/16" Long
C5, C8, C9	470 pF		
C6 C10, C11	0 001 µF	L3	9 3/4 Turns AWG #18, 3/16" I D, 1" Long
C7, C13	0 01 µF		
C12	0 1 µF		Tapped 1 3/4 Turns from Collector End
L1	3 Turns AWG #18, 1/4" I D 5/16" Long	L4, L5	0 47 µH Molded Choke
		R1, R2	10 Ohms

FIGURE 2 – BROADBAND TEST CIRCUIT



C1, C2	0.5 - 6 0 pF	L4	#30 AWG *Trifilar Wound* 1 9 9 Stackpole 57 0985, #11 Toroid
C3, C7	1500 pF Underwood		
C4, C5, C8	0 01 µF		
C6	470 pF	L5	Ferrite Choke, 3 Turns #30 on Stackpole 57 0156 Bead
L1	3 Turns #20 AWG, 5/32" I D	R1	20 Ohms
L2	0.84 µH, Ohmite Z235	R2	68 Ohms
L3	5 Turns #26 AWG, 5/32" I D	R3	150 Ohms
		R4	360 Ohms

FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

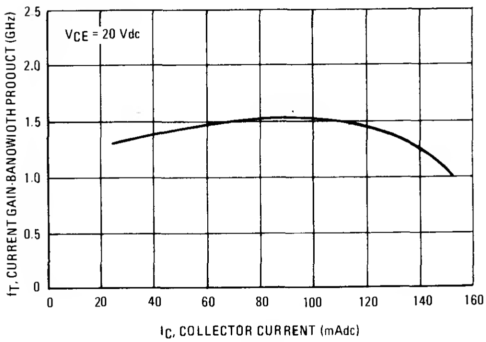


FIGURE 4 – CAPACITANCES

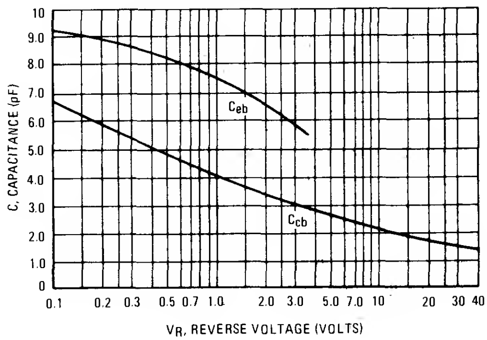


FIGURE 5 – COLLECTOR-EMITTER SATURATION VOLTAGE

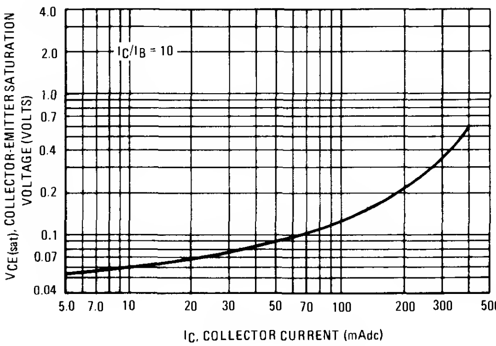


FIGURE 6 – BASE-EMITTER SATURATION VOLTAGE

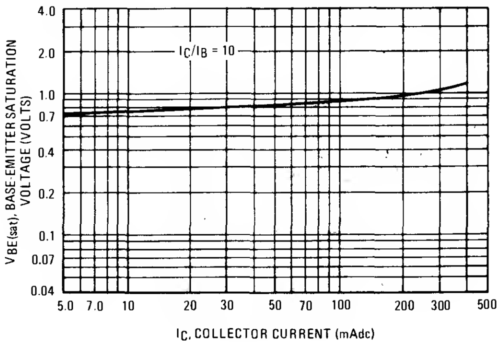


FIGURE 7 – NARROWBAND NOISE FIGURE versus CURRENT

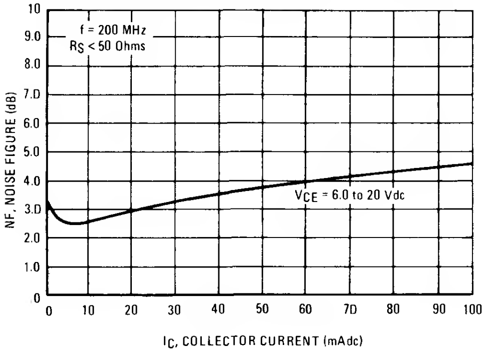


FIGURE 8 – BROADBAND NOISE FIGURE versus CURRENT

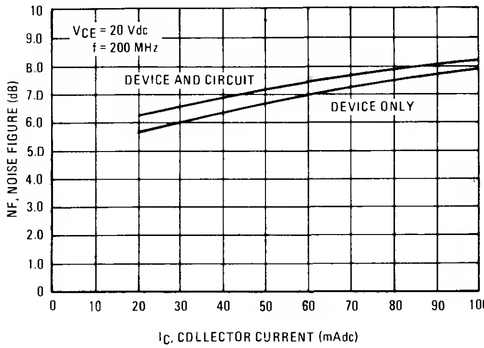
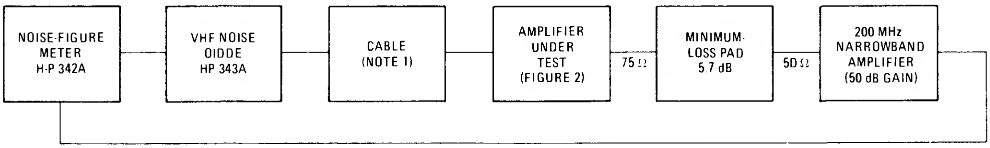


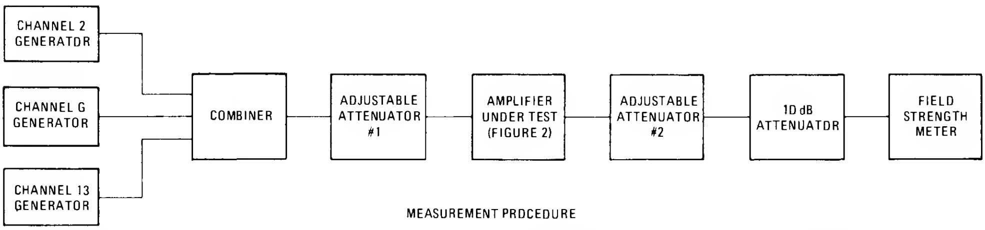
FIGURE 9 – NOISE FIGURE TEST SETUP



NOTE 1. RG-59 CABLE WITH ORIGINAL CENTER CONDUCTOR REPLACED WITH #30 WIRE. OVERALL LENGTH, INCLUDING BNC CONNECTORS, IS A QUARTER-WAVELENGTH AT 200 MHz (APPROX. 11 INCHES). USED TO MATCH IMPEDANCE OF NOISE DIODE TO AMPLIFIER UNDER TEST.

THE NOISE FIGURE OF THE POST-AMPLIFIERS AND MINIMUM LOSS PAD IS 8.4 dB.

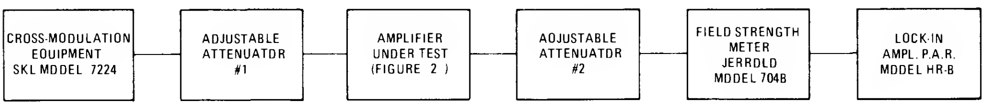
FIGURE 10 – INTERMODULATION DISTORTION TEST SETUP



MEASUREMENT PROCEDURE

1. ADJUST CHANNEL 2 GENERATOR FOR RATED OUTPUT FROM TEST AMPLIFIER (CHANNELS 6 & 13 OFF).
2. REPEAT FOR CHANNEL 6 (2 & 13 OFF) AND CHANNEL 13 (2 & 6 OFF). NOTE FOR REFERENCE THE FIELD STRENGTH METER READING FOR CHANNEL 13 (2 & 6 OFF).
3. TURN CHANNEL 13 OFF AND DRIVE THE TEST AMPLIFIER WITH CHANNELS 2 & 6. MEASURE THE LEVEL OF INTERMODULATION DISTORTION AT CHANNEL 13 RELATIVE TO THE REFERENCE LEVEL IN STEP 2.

FIGURE 11 – CROSS MODULATION DISTORTION TEST SETUP



MEASUREMENT PROCEDURE

1. ADJUST THE CROSSMODULATION EQUIPMENT FOR +50 dBmV OUTPUT FROM EACH CHANNEL.
2. ADJUST ATTENUATOR #1 FOR THE DESIRED OUTPUT LEVEL FROM THE TEST AMPLIFIER. ADJUST ATTENUATOR #2 TO MAINTAIN THE FIELD STRENGTH METER INPUT AT +10 dBmV.
3. WITH THE FIELD STRENGTH METER SELECT CHANNEL 13. USING THE WAVE ANALYZER MEASURE THE LEVEL OF THE MODULATION ON CHANNEL 13 DUE TO CROSS-MODULATION OF CHANNELS 2-12.

FIGURE 12 – CROSS MODULATION DISTORTION versus OUTPUT LEVEL

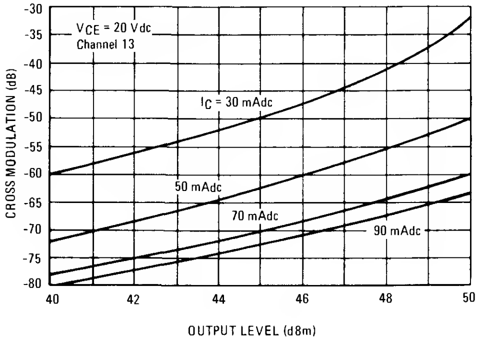
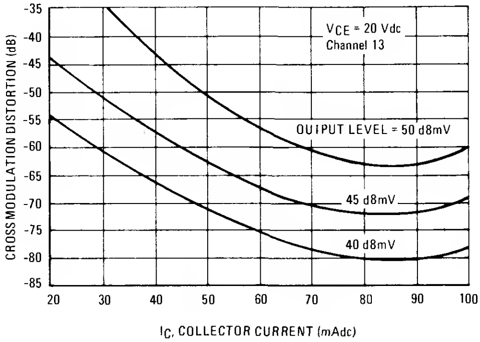


FIGURE 13 – CROSS MODULATION DISTORTION versus CURRENT



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2N6255

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

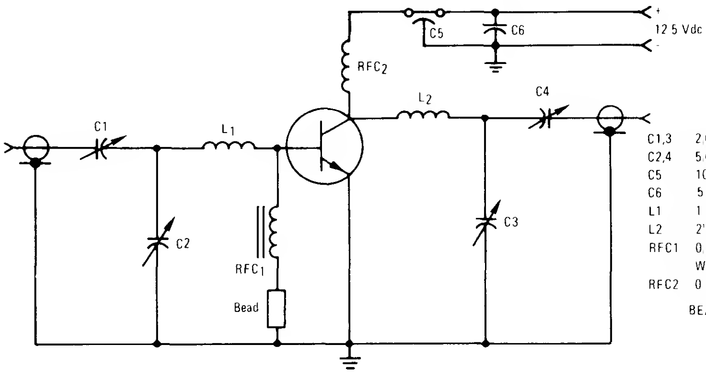
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.5	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.25	mAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	15	20	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 3.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	7.8	—	—	dB
Collector Efficiency (P_{out} = 3.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	50	—	—	%

FIGURE 1 – 175 MHz CIRCUIT



C1,3 2.0-50 pF ARCO 461 ELMENCO
C2,4 5.0-80 pF ARCO 462 ELMENCO
C5 1000 pF FEED THRU
C6 5.0 μF
L1 1 TURN #18 AWG ¼" I.D.
L2 2½ TURNS #18 AWG ¼" I.D.
RFC1 0.15 μH MOLDED CHOKE WITH BEAD ON GROUND LEG
RFC2 0.15 μH MOLDED CHOKE

BEAD IS FERROXCUBE 56 570 65 3B

FIGURE 2 – OUTPUT POWER versus INPUT POWER

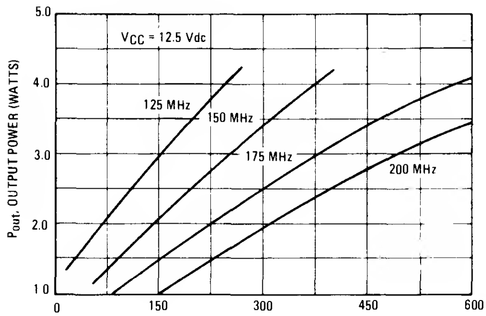


FIGURE 3 – OUTPUT POWER versus SUPPLY VOLTAGE

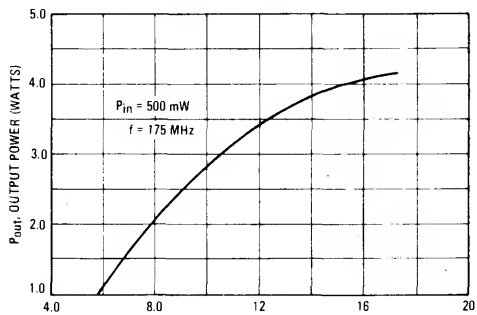


FIGURE 4 – COLLECTOR LOAD versus FREQUENCY

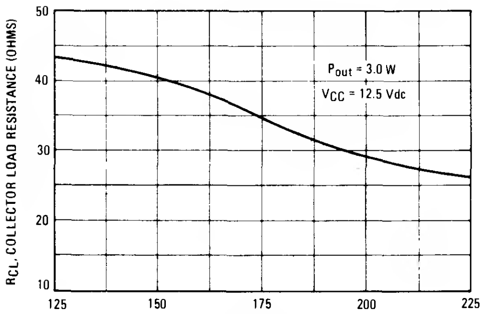


FIGURE 5 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

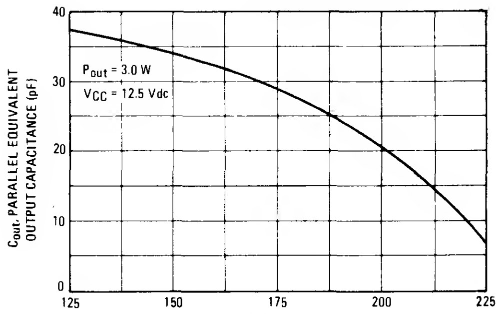


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

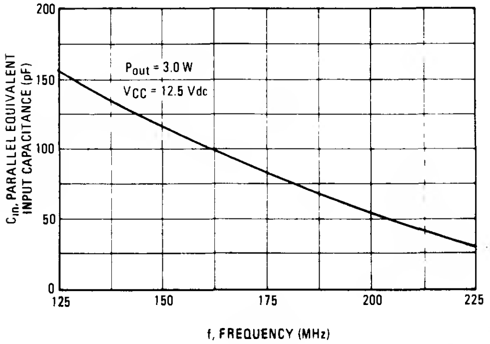
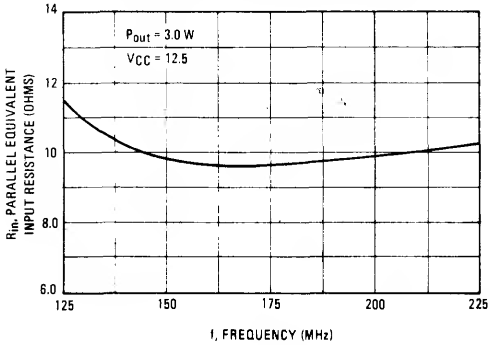


FIGURE 7 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY



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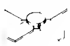
2N6256

CASE 249-05, STYLE 1

UHF AMPLIFIER TRANSISTOR

NPN SILICON



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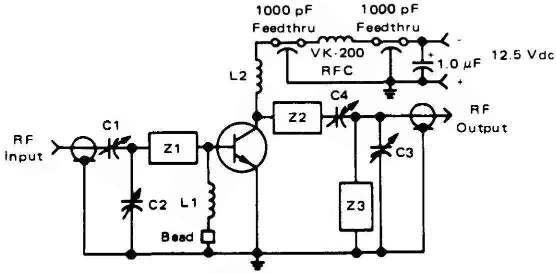
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 11.4	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.5	mAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_A = 125°C)	I_{CES}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	80	200	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	8.0	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figures 1, 6) (P_{out} = 0.5 W, V_{CC} = 12.5 Vdc, f = 470 MHz)	G_{PE}	7.0	9.0	—	dB
Collector Efficiency (Figures 1, 6) (P_{out} = 0.5 W, V_{CC} = 12.5 Vdc, f = 470 MHz)	η	60	70	—	%

FIGURE 1 – 470 MHz TEST CIRCUIT SCHEMATIC



NOTE: Test Circuit Layout and Component Descriptions Shown in Figure 6.

Typical Output Power curves were measured in circuit shown in Figure 6

FIGURE 2 – OUTPUT POWER versus FREQUENCY

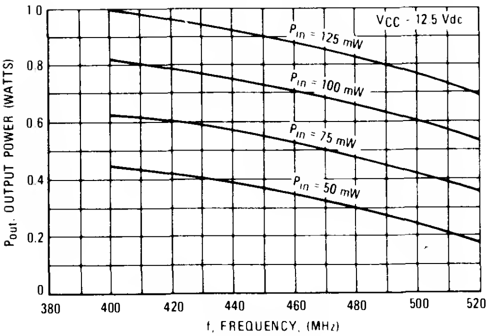


FIGURE 3 – OUTPUT POWER versus INPUT POWER

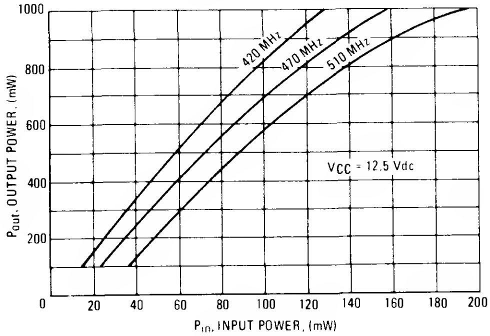


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

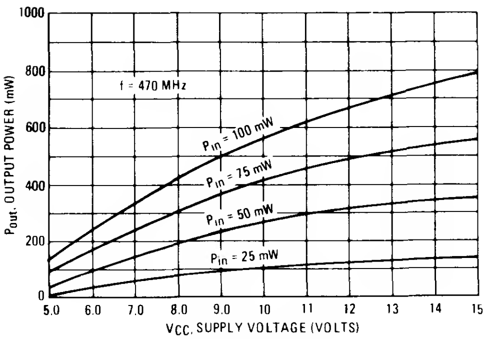


FIGURE 5 – SERIES EQUIVALENT INPUT and OUTPUT IMPEDANCE

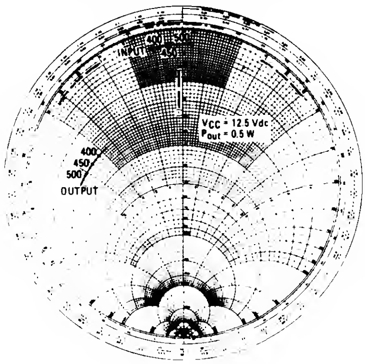


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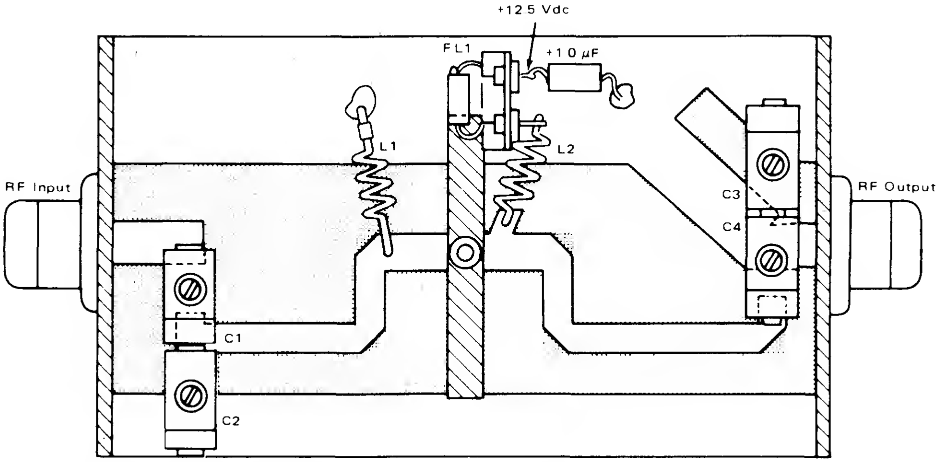
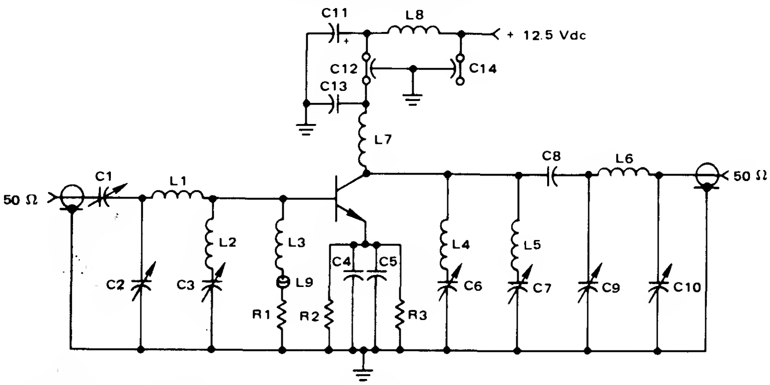
FIGURE 6 – 470 MHz TEST CIRCUIT LAYOUT
(See Figure 1 for Schematic Diagram)



C1,C2	1.0-25 pF ARCO 421 or Equivalent	FL1	DC Supply Filter	Connectors are Type "N"
C3, C4	1.0-25 pF ARCO 421 or Equivalent		2 1000 pF FT Capacitor	Board is Glass Teflon
L1, L2	7 Turns #22 AWG, 0.2" I.D		1 1.0 μF, 35 V Capacitor	3" x 5" x 0.060"
	Ferrite Bead FERROXCUBE 56 590 65 3B		1 Choke FERROXCUBE	Mounting Plate is 3" x 5" x 0.75"
	as shown on L1		VK 200 20 4B	

FIGURE 7 – 150 MHz to 450 MHz
TRIPLER USING 2N6256



C1,C2,C3,C9,C10	1-7 pF ARCO 400 or Equivalent	C13	0.1 μF Ceramic	L4	5 Turns 1/4" I.D.
C6,C7	1.5-20 pF ARCO 402 or Equivalent	R1	20 Ohm	L5	6 Turns 1/8" I.D.
C4,C5	470 pF ATC Type 100-B-420-m-ms	R2,R3	160 Ohm	L7	1 μH Molded Choke
C8	1000 pF UNDERWOOD Type J-101	L1	7 Turns 1/4" I.D.	L8	FERROXCUBE VK200-20/4B
C11	0.47 μF TANTALUM	L2	6-4 Turns 1/8" I.D.	L9	Ferrite Bead, FERROXCUBE 56-590-65/3B
C12,C14	470 pF Feedthru	L3	0.68 μH Molded Choke		

NOTE: All coils air core spece wound with #20 AWG Wire, unless otherwise specified.

Figure 7 shows the 2N6256 in a 150 MHz to 450 MHz tripler circuit. This circuit will typically produce 85 mW at 450 MHz with 30 mW at 150 MHz input (4.5 dB gain). Collector efficiency is 25% and all unwanted harmonics are at least 30 dB down from the 450 MHz output level.

It is important that each emitter lead be bypassed separately with a good hi-quality capacitor. The emitter resistor is likewise split in two with one-half on each emitter lead.

The input network is a modified "TEE" consisting of C1, C2, and L1, which matches the 50 Ohm input to the transistor impedance at 150 mc; this is roughly 18-j20 Ohms. The combination of L2 and C3 form a 450 MHz idler to provide a base return for third harmonic current. L4, C6 and L5, C7 are 150 MHz and 300 MHz output idlers respectively. The output matching section is a pi network made up of L6, C9 and C10. All coils are air core space-wound (turns one wire diameter apart) with #20 AWG wire.

2N6304
2N6305

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

7

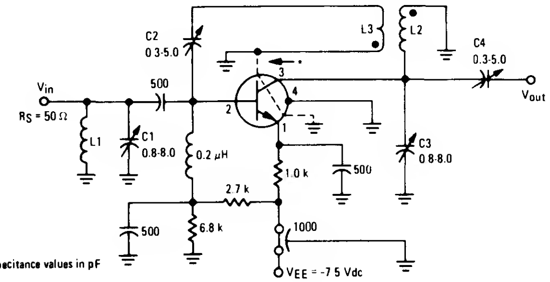
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	25	—	250	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	2N6304 2N6305	f_T	1400 1200	— —	— —	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	0.8	1.0	pF
Small Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}	25	—	250	—
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 5.0 Vdc, f = 31.8 MHz)	2N6304 2N6305	$r_b'C_c$	2.0 2.0	— —	12 15	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 50 ohms, f = 450 MHz) (Figure 1)	2N6304 2N6305	NF	— —	— —	4.5 5.5	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 450 MHz) (Figure 1)	2N6304 2N6305	G_{pe}	15 12	— —	— —	dB

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



Capacitance values in pF

L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.

L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.

* – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

FIGURE 2 – COLLECTOR-BASE CAPACITANCE versus COLLECTOR BASE VOLTAGE

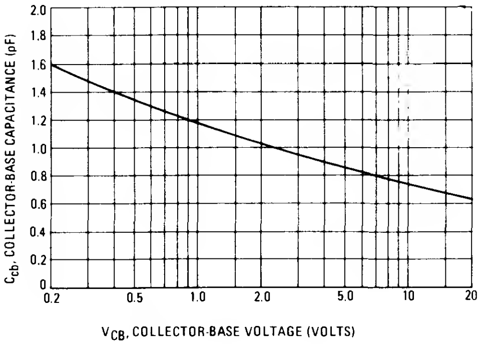


FIGURE 3 – CURRENT-GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

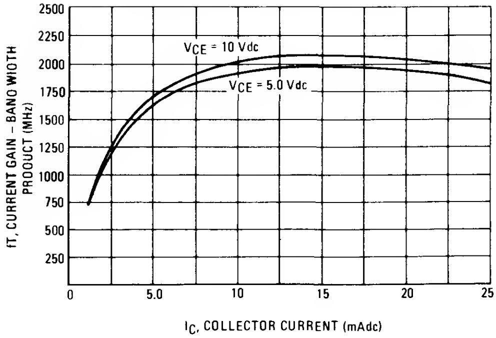


FIGURE 4 – COLLECTOR-BASE TIME CONSTANT versus EMITTER CURRENT

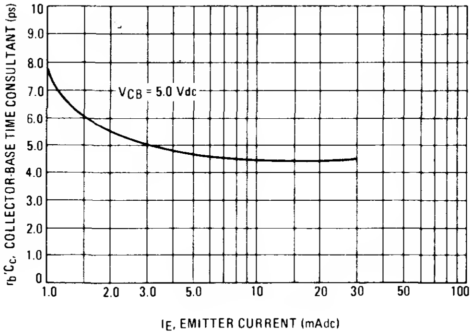


FIGURE 5 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

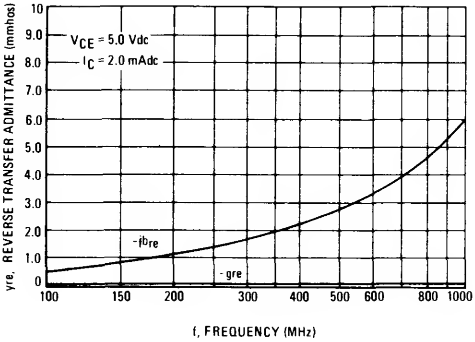


FIGURE 6 – INPUT ADMITTANCE versus FREQUENCY

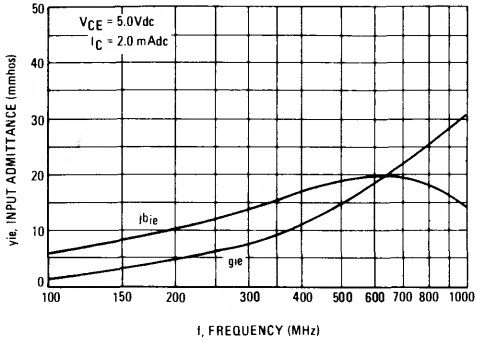


FIGURE 7 – OUTPUT ADMITTANCE versus FREQUENCY

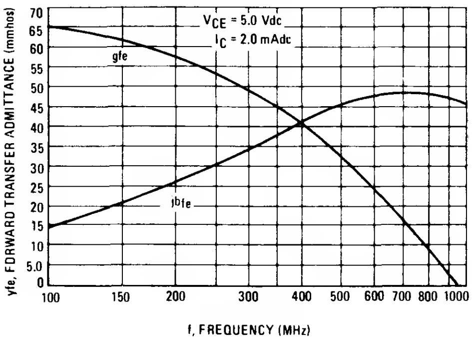


FIGURE 8 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

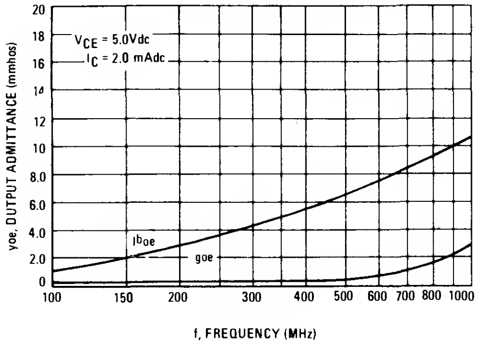


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FIGURE 9 – S_{11}, INPUT REFLECTION COEFFICIENT

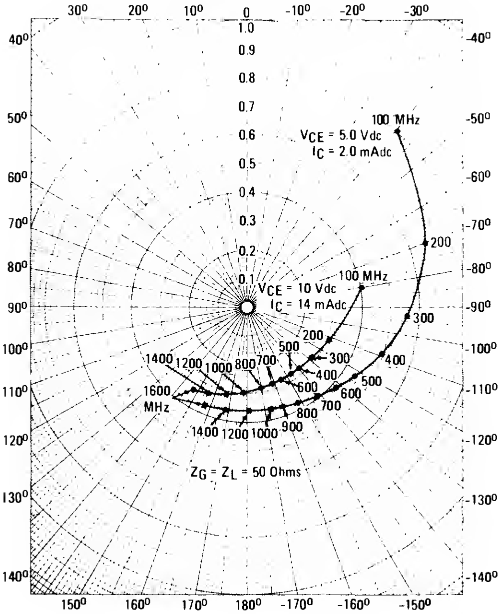

FIGURE 10 – S_{22}, OUTPUT REFLECTION COEFFICIENT

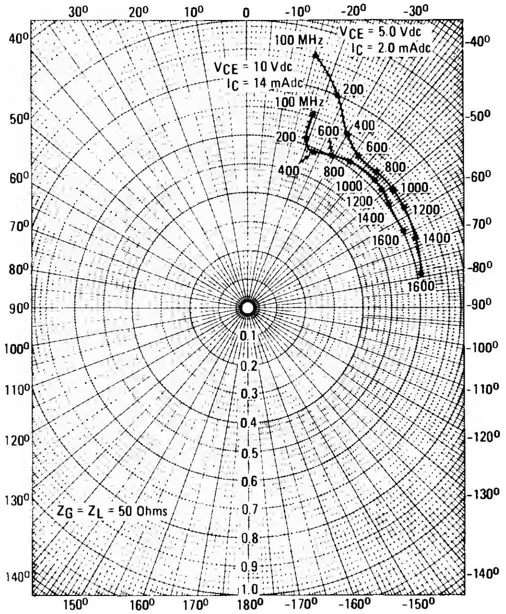

FIGURE 11 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

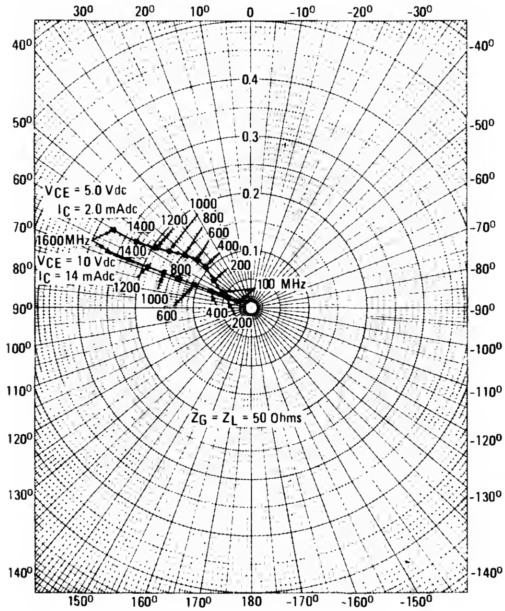

FIGURE 12 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

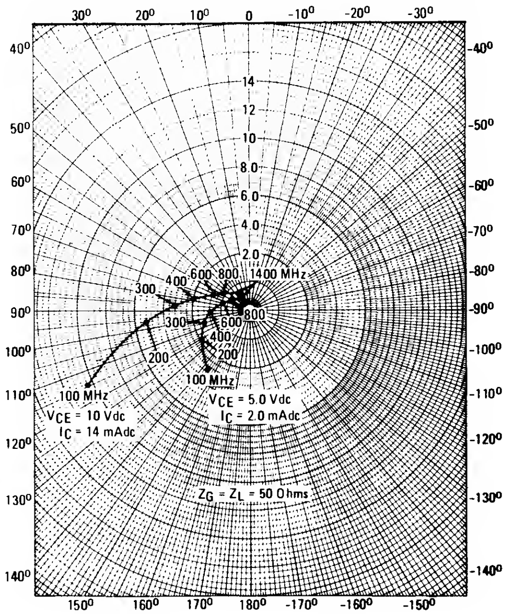

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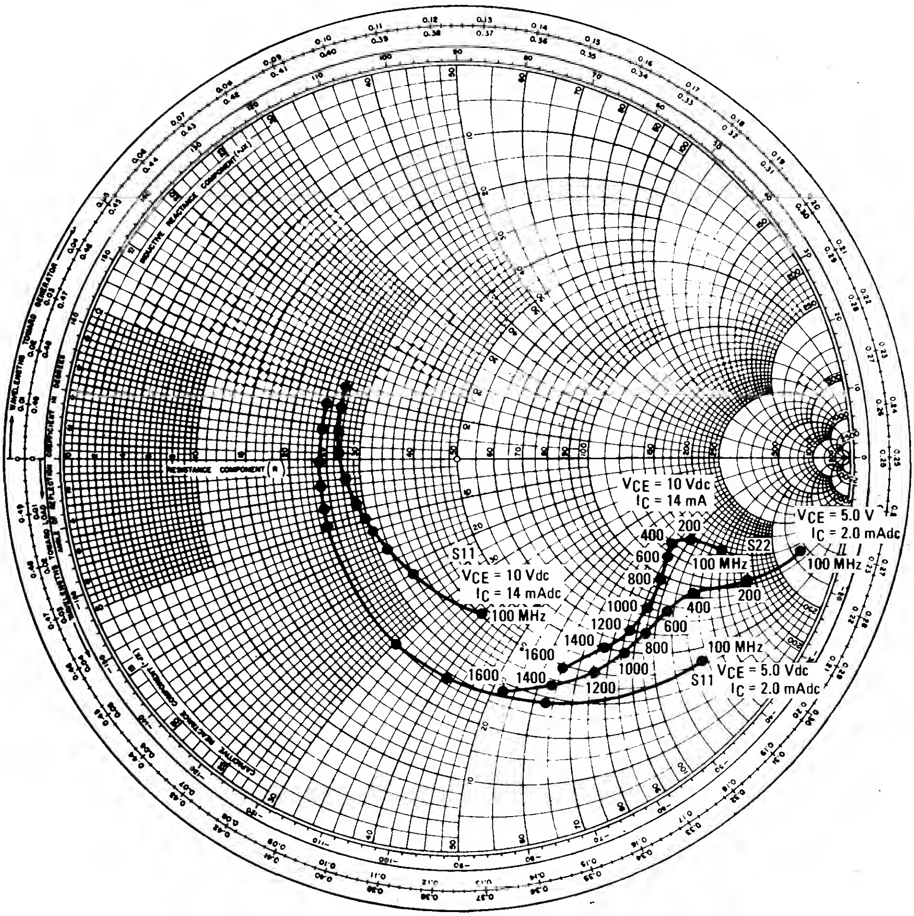
FIGURE 13 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



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2N6603

JAN, JTX, JTXV AVAILABLE
CASE 303-01, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS (T_A = 25°C Free Air Temperature)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_C = 125°C Derate above 125°C	P_D	400 5.33	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 15 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Collector-Base Capacitance(1) (V_{CB} = 10 Vdc, I_E = 0, 0.1 MHz ≤ f ≤ 1.0 MHz)	C_{cb}	0.25	—	0.75	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CE} = 10 Vdc, I_C = 15 mA, f = 1.0 GHz)	G_{pe}	15	—	21	dB
Spot Noise Figure (R_S = Optimum) (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	NF	1.0	—	2.5	dB
Power Gain at Optimum Noise Figure (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	G_{NF}	10	—	—	dB
TYPICAL 2 GHz PERFORMANCE					
Maximum Available Gain (Figure 1)(2) (V_{CE} = 10 Vdc, I_C = 15 mA, f = 2.0 GHz)	MAG	—	11	—	dB
Noise Figure (R_S = Optimum) (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 2.0 GHz)	NF	—	2.9	—	dB

(1) C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal of the bridge.

(2) MAG is calculated from the S-Parameters using the equation $MAG = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 – BLOCK DIAGRAM FOR POWER GAIN AND NOISE FIGURE

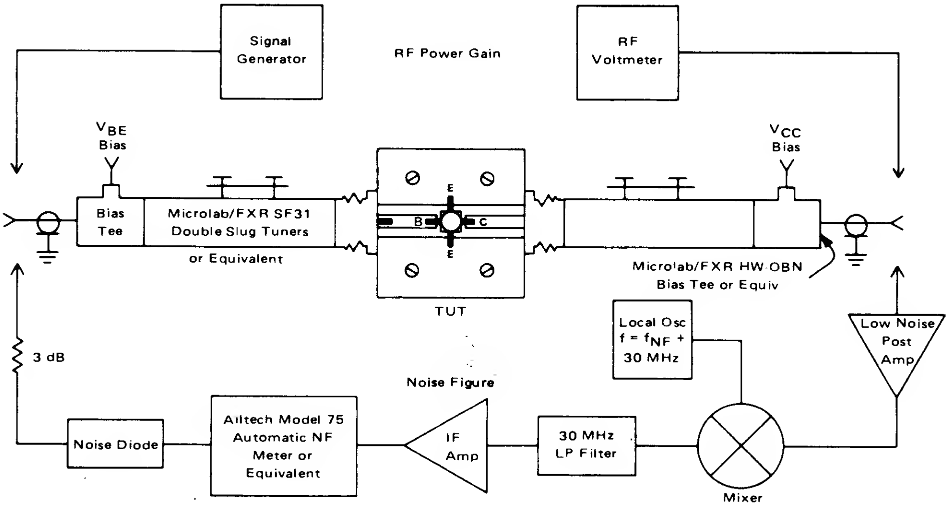


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

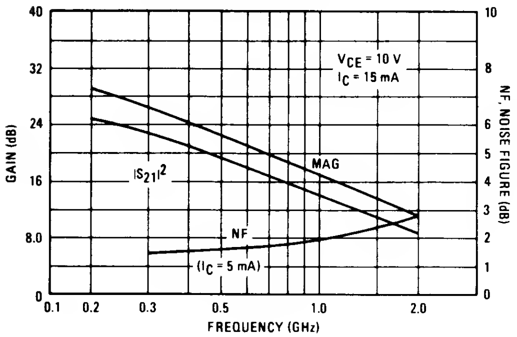


FIGURE 3 – OUTPUT CAPACITANCE versus VOLTAGE

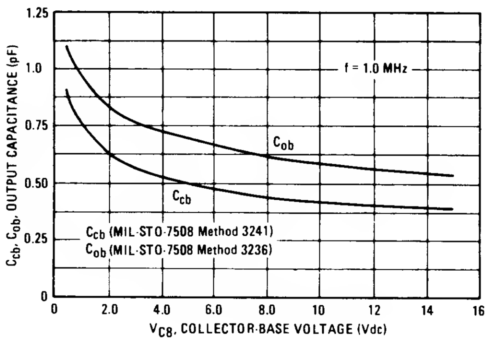


FIGURE 4 – CURRENT GAIN–BANDWIDTH PRODUCT versus COLLECTOR CURRENT

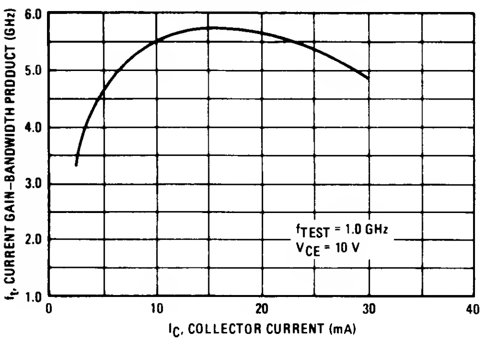


FIGURE 5 – POWER GAIN versus COLLECTOR CURRENT

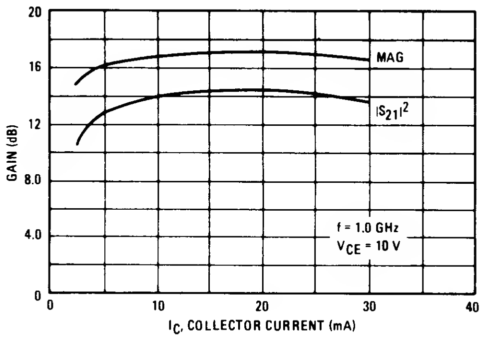
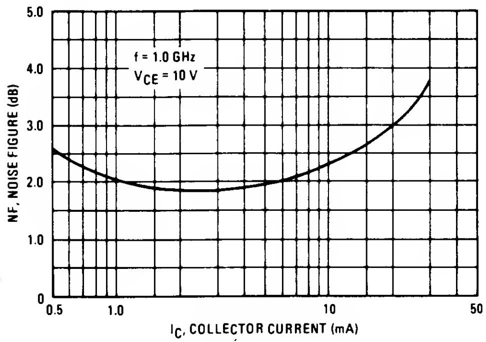


FIGURE 6 — NOISE FIGURE versus COLLECTOR CURRENT



COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 — INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY

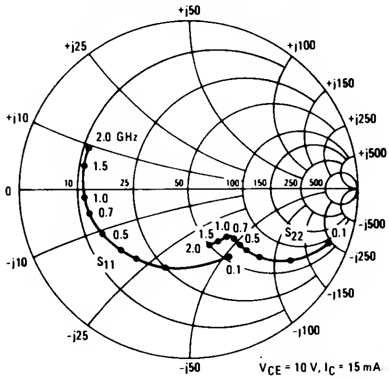
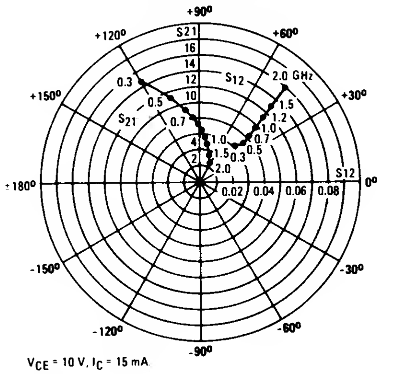


FIGURE 8 — FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



S – PARAMETERS

VCE (Volts)	IC (mA)	Frequency (MHz)	S11		S21		S12		S22	
			|S11|	∠φ	|S21|	∠φ	|S12|	∠φ	|S22|	∠φ
5.0	5	100	0.69	−30	12.16	160	0.026	72	0.95	−16
		200	0.65	−61	11.03	143	0.046	59	0.84	−31
		500	0.63	−122	7.05	111	0.074	36	0.56	−54
		1000	0.64	−158	4.13	88	0.087	28	0.39	−68
		2000	0.65	170	2.14	61	0.107	29	0.33	−91
	10	100	0.52	−50	18.74	154	0.022	69	0.91	−22
		200	0.54	−92	15.53	135	0.037	53	0.74	−40
		500	0.62	−146	8.49	104	0.052	38	0.43	−62
		1000	0.65	−172	4.66	84	0.065	37	0.29	−75
		2000	0.67	162	2.38	60	0.094	42	0.26	−97
	15	100	0.42	−70	22.72	150	0.019	66	0.87	−26
		200	0.51	−113	17.72	130	0.030	50	0.68	−44
		500	0.63	−157	8.96	100	0.042	41	0.38	−64
		1000	0.66	−178	4.80	82	0.056	44	0.26	−75
		2000	0.69	159	2.43	59	0.090	48	0.24	−97
	30	100	0.39	−116	24.57	142	0.014	62	0.80	−29
		200	0.55	−145	17.17	120	0.021	49	0.58	−42
		500	0.67	−171	7.96	95	0.030	49	0.34	−49
		1000	0.69	175	4.18	78	0.047	56	0.29	−56
		2000	0.71	157	2.13	55	0.084	58	0.29	−81
10	5	100	0.71	−27	12.01	161	0.021	73	0.96	−13
		200	0.67	−55	11.10	145	0.039	60	0.87	−25
		500	0.63	−115	7.44	114	0.064	39	0.62	−44
		1000	0.64	−153	4.43	90	0.077	30	0.46	−55
		2000	0.64	172	2.27	62	0.094	31	0.39	−76
	10	100	0.55	−43	18.77	155	0.018	71	0.92	−18
		200	0.55	−83	16.00	137	0.031	54	0.78	−32
		500	0.60	−140	9.06	106	0.046	39	0.49	−48
		1000	0.63	−168	5.02	85	0.058	39	0.36	−56
		2000	0.65	164	2.55	60	0.084	43	0.33	−76
	15	100	0.46	−60	23.14	152	0.016	68	0.90	−21
		200	0.51	−103	18.39	131	0.027	52	0.72	−36
		500	0.61	−152	9.67	102	0.037	42	0.43	−49
		1000	0.64	−175	5.21	83	0.049	45	0.33	−54
		2000	0.66	161	2.61	59	0.079	51	0.31	−74
	30	100	0.39	−98	27.29	144	0.013	63	0.83	−24
		200	0.53	−135	19.38	122	0.019	50	0.63	−35
		500	0.64	−167	9.11	96	0.027	48	0.41	−39
		1000	0.66	177	4.77	79	0.042	55	0.36	−45
		2000	0.69	157	2.41	56	0.074	58	0.35	−67

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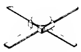
2N6604

JAN, JTX, JTXV AVAILABLE
CASE 303-01, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS (T_A = 25°C Free Air Temperature)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_C = 125°C Derate above 125°C	P_D	500 6.66	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Collector-Base Capacitance(1) (V_{CB} = 10 Vdc, I_E = 0, 0.1 MHz $\leq$ f $\leq$ 1.0 MHz)	C_{cb}	0.30	—	0.80	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 1.0 GHz)	G_{pe}	15	—	21	dB
Spot Noise Figure (R_S = Optimum) (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)	NF	1.5	—	3.0	dB
Power Gain at Optimum Noise Figure (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)	G_{NF}	9.0	—	—	dB
TYPICAL 2 GHz PERFORMANCE					
Maximum Available Gain (Figure 1)(2) (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 2.0 GHz)	MAG	—	10	—	dB
Noise Figure (R_S = Optimum) (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 2.0 GHz)	NF	—	4.3	—	dB

(1) C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal of the bridge.

(2) MAG is calculated from the S-Parameters using the equation $MAG = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 – BLOCK DIAGRAM FOR POWER GAIN AND NOISE FIGURE

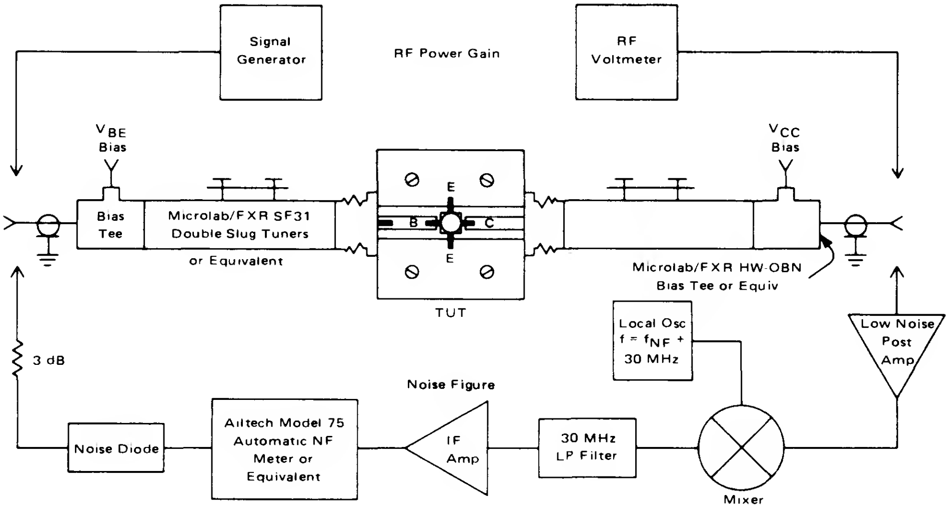


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

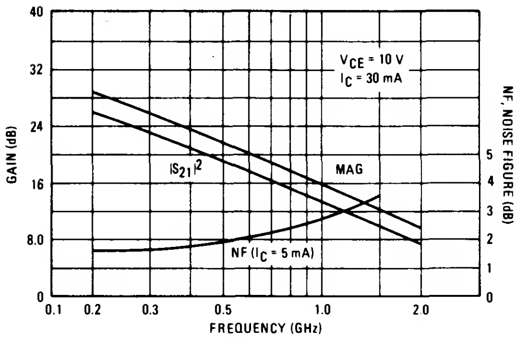


FIGURE 3 – OUTPUT CAPACITANCE versus VOLTAGE

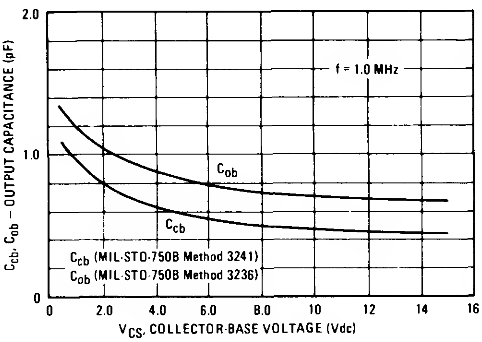


FIGURE 4 – CURRENT GAIN–BANDWIDTH PRODUCT versus COLLECTOR CURRENT

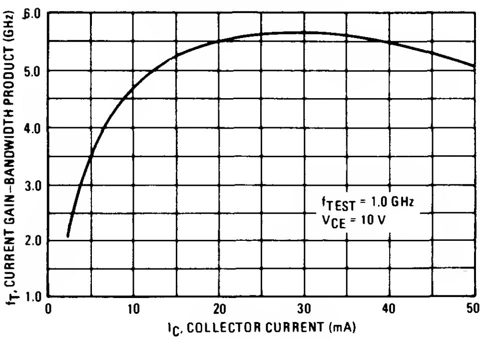
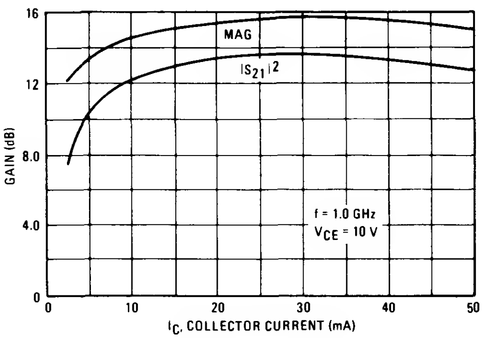
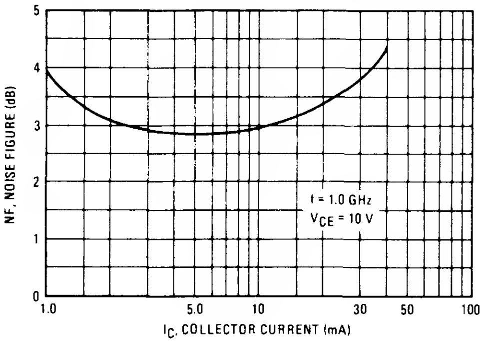


FIGURE 5 – POWER GAIN versus COLLECTOR CURRENT



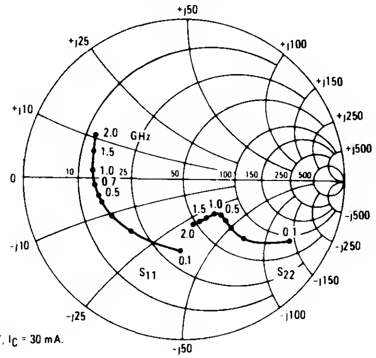
7

FIGURE 6 – NOISE FIGURE versus COLLECTOR CURRENT



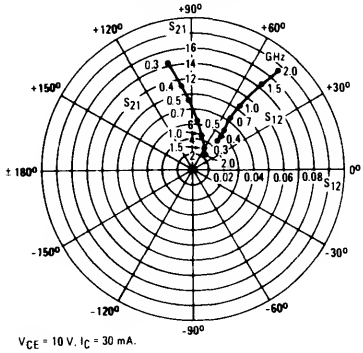
COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 – INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY



V_{CE} = 10 V, I_C = 30 mA.

FIGURE 8 – FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



V_{CE} = 10 V, I_C = 30 mA.

S – PARAMETERS

V_{CE} (Volts)	I_C (mA)	Frequency (MHz)	S11		S21		S12		S22	
			|S11|	∠φ	|S21|	∠φ	|S12|	∠φ	|S22|	∠φ
5.0	5	100	0.72	-40	12.37	153	0.028	67	0.91	-18
		200	0.65	-78	10.38	133	0.048	51	0.76	-32
		500	0.61	-137	5.75	100	0.067	34	0.50	-45
		1000	0.61	-168	3.13	78	0.082	31	0.41	-54
		2000	0.63	161	1.58	47	0.112	30	0.41	-80
	10	100	0.57	-60	19.54	146	0.024	63	0.85	-27
		200	0.55	-105	14.70	125	0.038	47	0.64	-43
		500	0.59	-155	7.12	95	0.051	39	0.37	-55
		1000	0.61	-178	3.77	76	0.069	40	0.29	-62
		2000	0.64	156	1.91	50	0.106	39	0.30	-86
	30	100	0.43	-111	30.58	135	0.016	57	0.72	-39
		200	0.53	-145	19.35	114	0.022	49	0.46	-57
		500	0.62	-173	8.42	91	0.035	51	0.24	-69
		1000	0.63	172	4.36	75	0.058	54	0.18	-76
		2000	0.67	151	2.19	52	0.099	49	0.21	-99
	50	100	0.46	-134	32.34	129	0.013	57	0.64	-42
		200	0.57	-158	19.19	110	0.018	51	0.40	-56
		500	0.64	-178	8.13	89	0.031	57	0.22	-62
		1000	0.65	170	4.17	74	0.053	58	0.19	-70
		2000	0.70	150	2.10	52	0.092	54	0.22	-97
10	5	100	0.74	-36	12.34	154	0.023	69	0.93	-15
		200	0.67	-71	10.56	135	0.040	54	0.81	-25
		500	0.59	-131	6.09	102	0.058	37	0.57	-36
		1000	0.58	-164	3.32	79	0.073	33	0.50	-44
		2000	0.60	164	1.67	48	0.098	32	0.49	-69
	10	100	0.60	-52	19.75	148	0.020	65	0.87	-21
		200	0.56	-95	15.30	127	0.032	49	0.69	-33
		500	0.56	-149	7.69	97	0.044	41	0.45	-41
		1000	0.58	-174	4.07	77	0.061	42	0.39	-47
		2000	0.61	159	2.03	50	0.095	40	0.39	-70
	30	100	0.44	-94	32.03	136	0.014	59	0.75	-31
		200	0.50	-135	20.76	115	0.021	49	0.52	-41
		500	0.57	-168	9.13	91	0.032	52	0.33	-43
		1000	0.59	175	4.71	75	0.052	54	0.29	-48
		2000	0.64	154	2.34	52	0.089	49	0.30	-72
	50	100	0.44	-117	33.56	129	0.012	59	0.68	-31
		200	0.52	-150	19.94	109	0.017	50	0.47	-36
		500	0.59	-174	8.52	89	0.028	56	0.34	-35
		1000	0.61	173	4.38	75	0.049	57	0.32	-43
		2000	0.66	152	2.21	51	0.083	52	0.34	-70

BFR90

CASE 317A-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 60°C Derate above 60°C	P_D	180 2.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 14 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	250	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 14 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	f_T	—	5.0	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.5	1.0	pF
FUNCTIONAL TEST					
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	NF	 — —	 2.4 3.0	 — —	dB
Power Gain at Optimum Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	G_{NF}	 — —	 15 10	 — —	dB
Maximum Available Power(1) (I_C = 14 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) (I_C = 14 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	G_{max}	 — —	 18 12	 — —	dB

(1) $G_{max} = \dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

FIGURE 1 – POWER DERATING

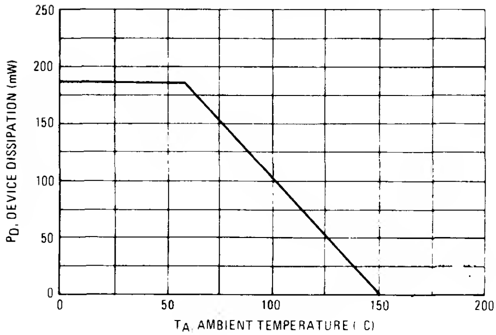


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

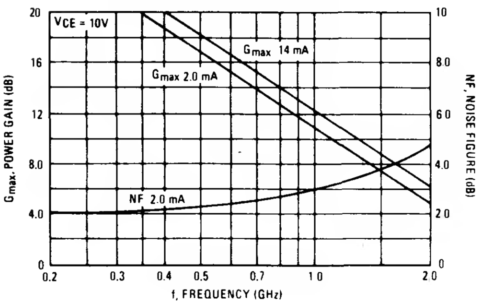


FIGURE 3 – POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

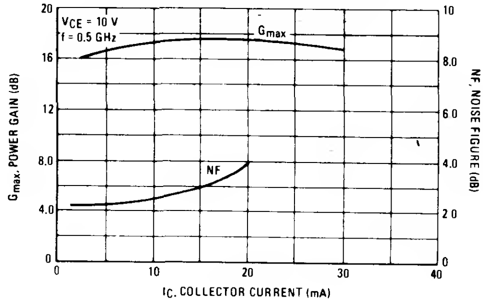


FIGURE 4 – S_{11} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
5.0	2.0	0.77	-45	0.48	-90	0.33	-125	0.27	-160	0.28	170
	5.0	0.52	-60	0.25	-110	0.18	-150	0.18	170	0.21	145
	10	0.33	-75	0.15	-125	0.13	-175	0.15	150	0.20	130
	20	0.20	-95	0.12	-155	0.14	165	0.17	145	0.22	130
	30	0.17	-116	0.14	-170	0.17	160	0.21	145	0.26	130
10	2.0	0.79	-40	0.50	-80	0.33	-115	0.26	-150	0.25	175
	5.0	0.56	-55	0.27	-95	0.16	-135	0.13	-175	0.17	150
	10	0.39	-65	0.16	-105	0.10	-150	0.10	165	0.15	140
	20	0.25	-75	0.10	-120	0.09	-175	0.12	150	0.18	130
	30	0.25	-75	0.10	-120	0.09	-175	0.12	150	0.18	130

FIGURE 5 – S_{22} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ
5.0	2.0	0.89	-20	0.69	-30	0.61	-35	0.55	-35	0.52	-45
	5.0	0.75	-25	0.55	-30	0.50	-30	0.47	-30	0.43	-40
	10	0.64	-25	0.49	-25	0.45	-25	0.43	-30	0.40	-35
	20	0.57	-25	0.47	-20	0.44	-25	0.43	-25	0.40	-35
	30	0.55	-20	0.47	-20	0.46	-20	0.44	-25	0.42	-35
10	2.0	0.91	-15	0.74	-25	0.66	-30	0.62	-35	0.59	-40
	5.0	0.79	-20	0.61	-25	0.56	-25	0.54	-30	0.51	-35
	10	0.70	-20	0.56	-20	0.53	-25	0.51	-25	0.48	-35
	20	0.63	-20	0.54	-25	0.53	-20	0.51	-25	0.49	-35
	30	0.63	-15	0.56	-15	0.55	-20	0.54	-25	0.52	-35

FIGURE 6 – S_{21} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S21	∠Φ	S21	∠Φ	S21	∠Φ	S21	∠Φ	S21	∠Φ
5.0	2.0	5.76	140	3.81	105	2.73	90	2.20	75	1.70	60
	5.0	9.92	125	5.24	95	3.50	80	2.80	70	2.10	60
	10	12.33	115	5.82	90	3.79	75	2.90	65	2.20	55
	20	13.62	105	6.00	85	3.88	75	2.95	65	2.25	55
	30	13.41	105	5.80	80	3.74	75	2.85	65	2.15	55
10	2.0	5.77	145	3.88	110	2.80	90	2.25	75	1.75	60
	5.0	10.05	130	5.42	95	3.60	80	2.85	70	2.10	60
	10	12.56	115	6.00	90	3.90	80	3.05	70	2.25	55
	20	13.77	110	6.13	85	3.92	75	3.05	65	2.20	55
	30	13.23	105	5.79	85	3.70	75	2.85	65	2.15	55

FIGURE 7 – S_{12} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S12	∠Φ	S12	∠Φ	S12	∠Φ	S12	∠Φ	S12	∠Φ
5.0	2.0	0.06	65	0.10	55	0.12	55	0.14	55	0.17	60
	5.0	0.05	65	0.08	65	0.12	65	0.15	65	0.19	65
	10	0.04	65	0.08	70	0.12	70	0.15	70	0.20	65
	20	0.04	75	0.08	75	0.12	75	0.15	70	0.20	70
	30	0.03	75	0.07	75	0.11	75	0.15	75	0.19	70
10	2.0	0.05	70	0.03	55	0.11	55	0.12	55	0.15	60
	5.0	0.04	65	0.07	65	0.10	65	0.13	65	0.17	70
	10	0.04	65	0.07	70	0.10	70	0.13	70	0.17	70
	20	0.03	70	0.07	75	0.10	75	0.13	75	0.17	70
	30	0.03	75	0.06	75	0.10	75	0.13	75	0.17	70

BFR91

CASE 317A-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	35	mAdc
Total Device Dissipation @ T_A = 60°C Derate above 60°C	P_D	180 2.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	25	—	250	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 30 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz)	f_T	—	5.0	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.7	1.0	pF
FUNCTIONAL TEST					
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 GHz)	NF	 — —	 1.9 2.5	 — —	dB
Power Gain at Optimum Noise Figure (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 GHz)	G_{NF}	 — —	 11 8.0	 — —	dB
Maximum Available Power(1) (I_C = 30 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz) (I_C = 30 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 GHz)	G_{max}	 — —	 16 10	 — —	dB

(1) $G_{max} = \dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

FIGURE 1 — POWER DERATING

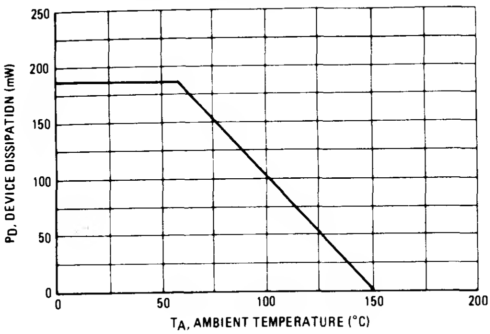


FIGURE 2 - POWER GAIN AND NOISE FIGURE versus FREQUENCY

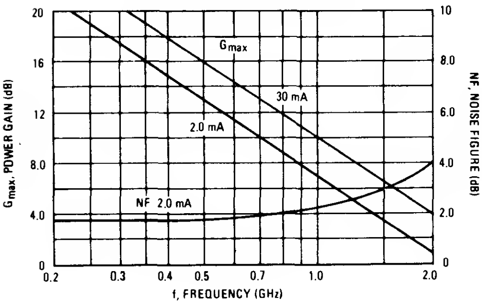


FIGURE 3 - POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

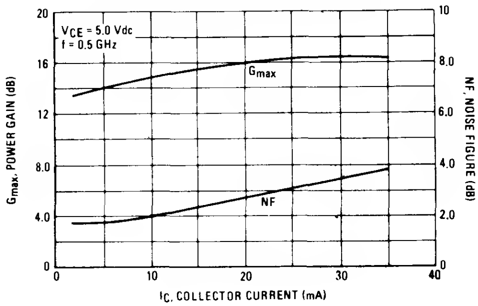


FIGURE 4 — S_{11} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S11	∠Φ	S11	∠Φ	S11	∠Φ	S11	∠Φ	S11	∠Φ
5.0	2.0	0.72	-65	0.51	-125	0.46	-165	0.47	170	0.51	145
	5.0	0.49	-90	0.35	-150	0.34	175	0.36	155	0.41	135
	10	0.34	-110	0.28	-165	0.29	165	0.32	145	0.36	130
	20	0.26	-130	0.24	180	0.27	155	0.30	140	0.34	125
	30	0.24	-145	0.24	175	0.27	155	0.30	140	0.34	125
10	2.0	0.74	-60	0.51	-120	0.45	-160	0.45	170	0.49	150
	5.0	0.52	-80	0.33	-140	0.31	-175	0.32	160	0.37	145
	10	0.36	-95	0.24	-155	0.24	170	0.27	155	0.31	140
	20	0.25	-115	0.19	-170	0.21	160	0.24	145	0.29	130
	30	0.22	-120	0.19	-175	0.21	160	0.25	145	0.20	130

FIGURE 5 — S_{22} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S22	∠Φ	S22	∠Φ	S22	∠Φ	S22	∠Φ	S22	∠Φ
5.0	2.0	0.83	-25	0.62	-35	0.55	-40	0.51	-45	0.49	-60
	5.0	0.66	-30	0.45	-35	0.40	-40	0.37	-40	0.34	-50
	10	0.52	-35	0.36	-35	0.32	-35	0.30	-35	0.27	-50
	20	0.42	-35	0.30	-30	0.27	-30	0.26	-30	0.22	-45
	30	0.38	-35	0.28	-25	0.26	-30	0.25	-30	0.21	-40
10	2.0	0.86	-20	0.67	-30	0.62	-35	0.58	-40	0.56	-50
	5.0	0.71	-25	0.53	-30	0.48	-30	0.45	-35	0.43	-45
	10	0.59	-30	0.45	-25	0.41	-30	0.40	-30	0.37	-40
	20	0.50	-25	0.40	-25	0.38	-25	0.37	-30	0.34	-40
	30	0.47	-25	0.40	-20	0.38	-25	0.37	-30	0.34	-35

FIGURE 6 – S_{21} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
5.0	2.0	5.25	130	3.06	95	2.10	75	1.70	65	1.20	50
	5.0	8.72	120	4.34	90	2.84	75	2.30	65	1.60	50
	10	10.85	110	4.92	85	3.22	70	2.60	65	1.80	50
	20	12.13	105	5.34	80	3.44	70	2.75	60	1.90	50
	30	12.50	100	5.42	80	3.47		2.75	60	1.90	50
10	2.0	5.36	135	3.20	95	2.20	80	1.85	65	1.30	50
	5.0	9.05	120	4.55	90	3.00	75	2.45	65	1.65	50
	10	11.37	110	5.22	85	3.40	75	2.65	65	1.85	50
	20	12.83	105	5.64	80	3.63	70	2.75	60	2.00	50
	30	13.10	100	5.62	80	3.63	70	2.75	60	2.00	50

FIGURE 7 – S_{12} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ
5.0	2.0	0.08	55	0.11	45	0.12	50	0.14	55	0.17	65
	5.0	0.06	55	0.09	60	0.13	65	0.17	65	0.22	65
	10	0.05	60	0.09	65	0.14	70	0.19	65	0.24	65
	20	0.05	70	0.07	70	0.15	70	0.19	70	0.25	65
	30	0.04	75	0.10	75	0.15	70	0.19	70	0.25	65
10	2.0	0.06	60	0.09	45	0.10	50	0.12	60	0.15	70
	5.0	0.05	60	0.08	60	0.11	65	0.15	65	0.19	70
	10	0.05	65	0.08	65	0.12	70	0.16	70	0.21	70
	20	0.04	70	0.08	70	0.13	70	0.17	70	0.22	70
	30	0.04	70	0.08	75	0.13	70	0.17	70	0.22	70

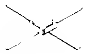
BFR96

CASE 317A-01, STYLE 2

MRF961

CASE 317-01, STYLE 2

MRF962



CASE 303-01, STYLE 1

MRF965

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BRF96 MRF961	MRF962 MRF965	Unit
Collector-Emitter Voltage	V_{CEO}	15	15	Vdc
Collector-Base Voltage	V_{CBO}	20	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	3.0	Vdc
Collector Current — Continuous	I_C	100	100	mAdc
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	0.5 5.0	0.75 7.5	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +150	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, Emitter Guarded) BFR96, MRF961, MRF962 MRF965	C_{cb}	— —	1.2 1.6	1.5 2.0	pF
FUNCTIONAL TEST					
Noise Figure (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	NF	—	2.0	—	dB
Maximum Available Gain/Insertion Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) BFR96, MRF965 MRF961 MRF962	MAG/$\|S_{21}\|^2$	−/12 −/13.5 −/15	14.5/13 17/15 20.5/16.5	— — —	dB

NOTE 1. MAG $= \dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

FIGURE 1 – MAXIMUM AVAILABLE GAIN versus FREQUENCY

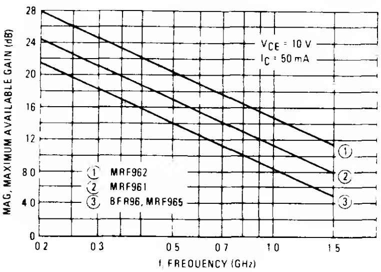


FIGURE 2 – $|S_{21}|^2$ versus FREQUENCY

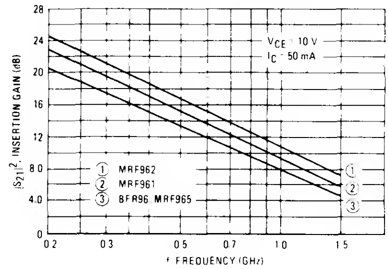


FIGURE 3 – MAXIMUM AVAILABLE GAIN versus COLLECTOR CURRENT

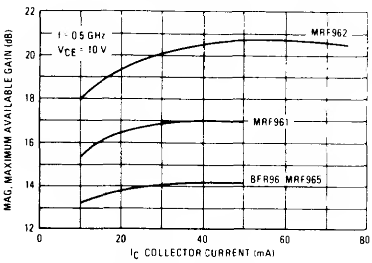


FIGURE 4 – GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

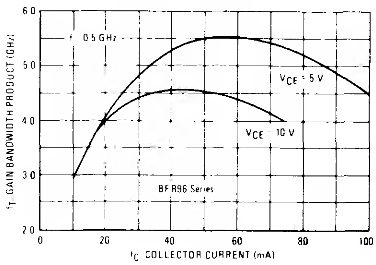


FIGURE 5 – NOISE FIGURE versus FREQUENCY

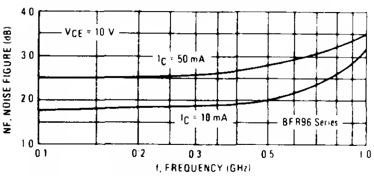


FIGURE 6 – NOISE FIGURE versus COLLECTOR CURRENT

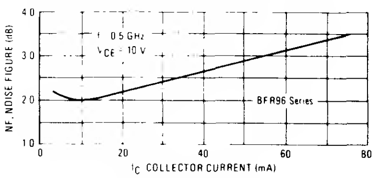


FIGURE 7 – COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

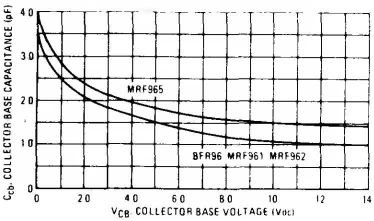


FIGURE 8 – OUTPUT POWER AND EFFICIENCY versus INPUT POWER (MRF965)

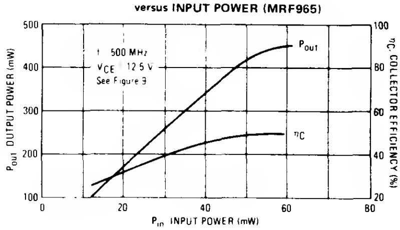
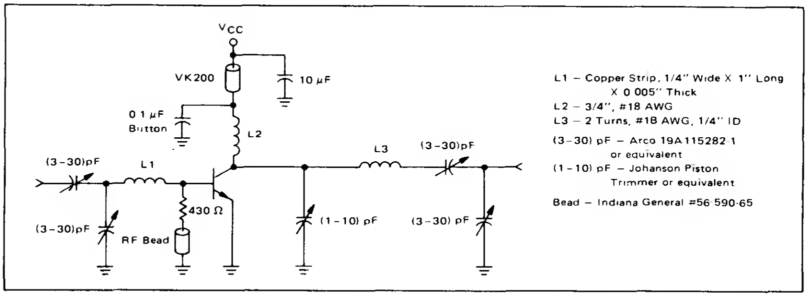
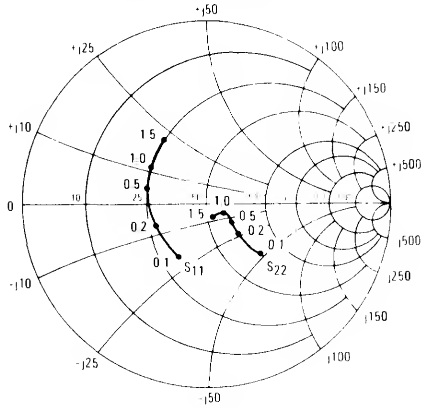


FIGURE 9 – MRF965 CLASS C AMPLIFIER @ 500 MHz, 400 mW

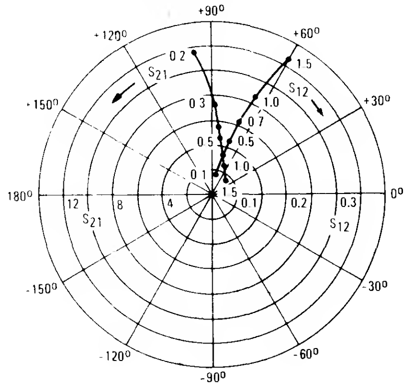


BFR96 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 50 mA)



FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 50 mA)

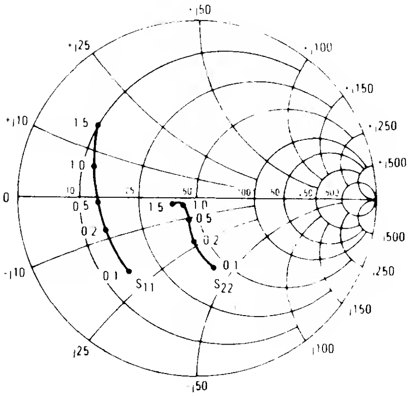


V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11} |S11|	S_{11} ∠φ	S_{21} |S21|	S_{21} ∠φ	S_{12} |S12|	S_{12} ∠φ	S_{22} |S22|	S_{22} ∠φ
5.0	10	100	0.51	-95	15.04	121	0.047	54	0.58	-48
		300	0.43	-163	5.87	92	0.082	58	0.26	-63
		500	0.46	174	3.61	79	0.120	63	0.19	-63
		700	0.48	162	2.65	68	0.161	63	0.15	-64
		1000	0.48	146	1.92	57	0.220	63	0.12	-79
		1500	0.54	121	1.40	43	0.320	58	0.13	-118
	25	100	0.39	-122	19.41	112	0.037	60	0.42	-68
		300	0.39	-176	6.81	89	0.079	68	0.16	-94
		500	0.42	166	4.11	78	0.129	70	0.10	-103
		700	0.44	156	3.05	69	0.176	68	0.06	-119
		1000	0.44	142	2.20	59	0.244	64	0.06	-159
		1500	0.49	118	1.62	45	0.348	57	0.10	177
	50	100	0.35	-140	21.10	106	0.032	64	0.33	-81
		300	0.38	176	7.11	88	0.081	72	0.13	-116
		500	0.42	162	4.28	78	0.133	72	0.09	-136
		700	0.43	153	3.16	70	0.183	69	0.07	-163
		1000	0.42	140	2.28	60	0.252	65	0.08	165
		1500	0.47	116	1.66	47	0.357	57	0.12	155
10	10	100	0.53	-83	15.96	124	0.039	58	0.65	-36
		300	0.38	-154	6.44	94	0.070	59	0.35	-41
		500	0.41	-179	3.98	81	0.102	64	0.30	-39
		700	0.42	166	2.94	70	0.138	65	0.27	-39
		1000	0.42	151	2.12	60	0.191	66	0.24	-47
		1500	0.49	125	1.50	44	0.278	63	0.22	-72
	25	100	0.38	-104	20.85	115	0.032	60	0.48	-48
		300	0.32	-169	7.54	91	0.070	68	0.23	-48
		500	0.35	170	4.61	80	0.109	71	0.19	-43
		700	0.37	160	3.37	70	0.152	69	0.16	-39
		1000	0.37	146	2.43	61	0.210	67	0.13	-44
		1500	0.43	121	1.73	47	0.304	61	0.10	-74
	50	100	0.33	-119	22.59	109	0.029	63	0.39	-51
		300	0.30	-176	7.74	88	0.069	72	0.19	-47
		500	0.34	166	4.70	79	0.113	73	0.16	-40
		700	0.36	158	3.45	70	0.156	70	0.14	-35
		1000	0.36	144	2.46	61	0.217	66	0.11	-39
		1500	0.42	119	1.75	47	0.310	60	0.08	-72

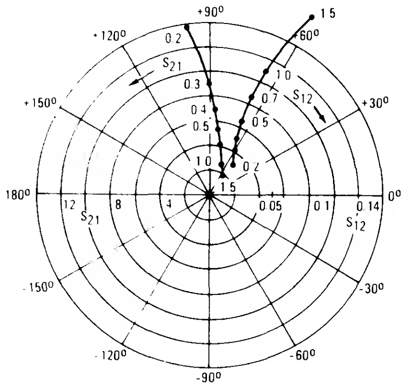
7

MRF961 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 50 mA)



FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 50 mA)

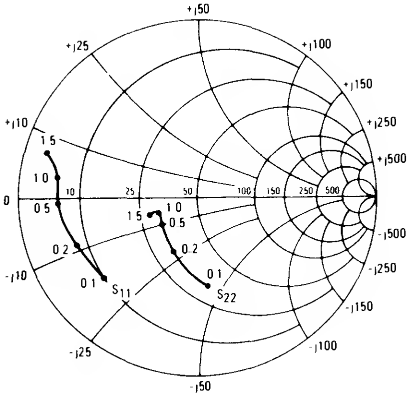


V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠φ	$\lvert S_{21}\rvert$	∠φ	$\lvert S_{12}\rvert$	∠φ	$\lvert S_{22}\rvert$	∠φ
5.0	10	100	0.65	-101	16.61	125	0.047	46	0.61	-56
		300	0.64	-160	6.61	96	0.064	39	0.27	-87
		500	0.66	-178	4.01	83	0.078	45	0.19	-98
		700	0.68	171	2.93	73	0.093	49	0.16	-108
		1000	0.68	160	2.07	63	0.119	53	0.16	-124
		1500	0.72	143	1.43	50	0.158	54	0.21	-141
	25	100	0.60	-129	22.41	115	0.034	44	0.49	-84
		300	0.63	-172	7.94	93	0.049	50	0.26	-132
		500	0.66	174	4.78	83	0.071	58	0.21	-150
		700	0.67	166	3.45	75	0.092	60	0.20	-164
		1000	0.67	156	2.46	66	0.124	61	0.21	-177
		1500	0.71	140	1.73	54	0.173	60	0.24	175
	50	100	0.59	-147	25.12	109	0.025	46	0.42	-104
		300	0.64	-178	8.47	91	0.046	60	0.28	-151
		500	0.67	171	5.05	83	0.070	65	0.26	-167
		700	0.68	164	3.67	75	0.093	65	0.25	-178
		1000	0.67	154	2.60	67	0.128	65	0.26	170
		1500	0.72	138	1.83	56	0.178	62	0.29	163
10	10	100	0.65	-90	17.47	128	0.040	50	0.67	-41
		300	0.61	-154	7.31	97	0.057	41	0.33	-57
		500	0.62	-174	4.46	84	0.069	46	0.25	-58
		700	0.64	175	3.27	74	0.084	50	0.22	-60
		1000	0.64	163	2.33	64	0.106	54	0.20	-72
		1500	0.69	145	1.56	50	0.140	57	0.22	-96
	25	100	0.57	-116	24.36	119	0.030	48	0.51	-62
		300	0.58	-167	8.10	94	0.045	52	0.20	-89
		500	0.61	178	5.43	83	0.070	58	0.14	-97
		700	0.63	169	3.93	75	0.084	60	0.10	-106
		1000	0.62	159	2.78	66	0.112	61	0.09	-124
		1500	0.67	142	1.91	53	0.156	60	0.12	-140
	50	100	0.55	-132	26.97	112	0.024	47	0.40	-73
		300	0.57	-173	9.32	91	0.042	59	0.16	-104
		500	0.60	174	5.58	82	0.064	64	0.11	-115
		700	0.62	167	4.04	74	0.086	64	0.08	-128
		1000	0.61	158	2.85	66	0.115	64	0.08	-149
		1500	0.67	141	1.96	55	0.158	61	0.12	-158

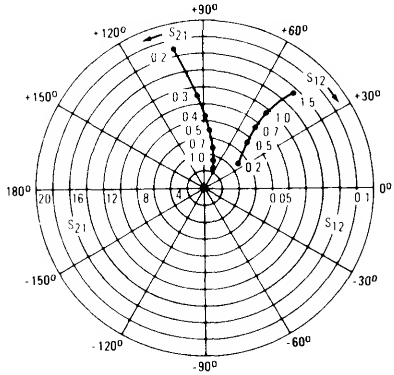
7

MRF962 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY
(V_{CE} = 10 V, I_C = 50 mA)



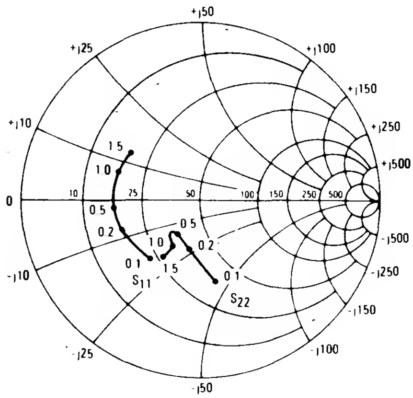
FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY
(V_{CE} = 10 V, I_C = 50 mA)



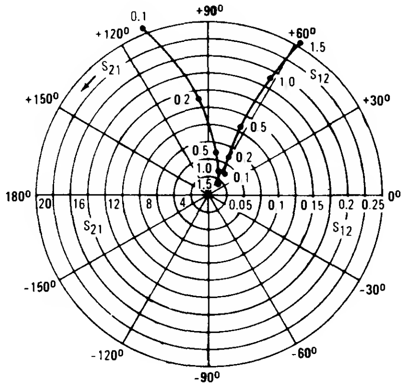
V_{CE} (Volts)	I_C (mA)	f (MHz)	S11 $\lvert S_{11}\rvert$	S11 ∠φ	S21 $\lvert S_{21}\rvert$	S21 ∠φ	S12 $\lvert S_{12}\rvert$	S12 ∠φ	S22 $\lvert S_{22}\rvert$	S22 ∠φ
5.0	10	100	0.70	-102	17.42	128	0.044	43	0.65	-57
		300	0.75	-156	7.11	98	0.058	24	0.32	-97
		500	0.78	-170	4.36	86	0.064	25	0.26	-110
		700	0.78	-176	3.16	77	0.071	26	0.23	-117
		1000	0.78	176	2.26	67	0.078	27	0.24	-126
		1500	0.79	167	1.51	54	0.092	29	0.31	-133
	25	100	0.69	-131	24.24	118	0.029	38	0.56	-87
		300	0.77	-167	8.76	95	0.039	32	0.35	-137
		500	0.79	-176	5.26	85	0.046	36	0.32	-150
		700	0.80	178	3.82	78	0.055	40	0.31	-158
		1000	0.79	173	2.72	70	0.067	42	0.32	-164
		1500	0.81	164	1.82	59	0.086	42	0.34	-167
	50	100	0.71	-147	27.72	113	0.021	37	0.53	-107
		300	0.78	-173	9.59	94	0.030	40	0.41	-152
		500	0.81	179	5.72	85	0.038	46	0.39	-163
		700	0.81	176	4.09	78	0.048	50	0.38	-169
		1000	0.81	171	2.89	71	0.061	51	0.38	-175
		1500	0.82	163	1.96	62	0.082	49	0.40	-177
10	10	100	0.71	-92	18.77	131	0.037	47	0.70	-44
		300	0.74	-150	8.09	100	0.051	28	0.34	-69
		500	0.75	-166	5.01	87	0.056	28	0.27	-75
		700	0.76	-174	3.62	78	0.064	28	0.24	-79
		1000	0.76	179	2.58	69	0.071	30	0.24	-88
		1500	0.77	168	1.72	55	0.085	31	0.31	-104
	25	100	0.67	-120	27.10	122	0.027	42	0.57	-68
		300	0.73	-163	10.27	97	0.035	36	0.27	-110
		500	0.76	-174	6.21	86	0.043	39	0.22	-124
		700	0.77	-179	4.48	78	0.051	41	0.20	-132
		1000	0.77	175	3.19	71	0.062	43	0.20	-139
		1500	0.78	166	2.13	59	0.080	42	0.25	-142
	50	100	0.68	-137	31.53	116	0.020	37	0.49	-85
		300	0.74	-169	11.17	95	0.028	40	0.27	-131
		500	0.77	-177	6.69	85	0.037	46	0.24	-144
		700	0.77	178	4.82	78	0.047	48	0.23	-152
		1000	0.77	173	3.42	71	0.059	50	0.23	-158
		1500	0.79	165	2.30	61	0.078	47	0.27	-159

MRF965 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION
COEFFICIENTS versus FREQUENCY
(V_{CE} = 10 V, I_C = 50 mA)



FORWARD/REVERSE TRANSMISSION
COEFFICIENTS versus FREQUENCY
(V_{CE} = 10 V, I_C = 50 mA)



V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠φ	$\|S_{21}\|$	∠φ	$\|S_{12}\|$	∠φ	$\|S_{22}\|$	∠φ
5.0	10	100	0.56	-102	13.87	121	0.054	48	0.58	-62
		300	0.57	-158	5.47	90	0.084	46	0.32	-94
		500	0.56	-169	3.40	77	0.110	52	0.27	-106
		700	0.52	178	2.53	69	0.136	54	0.39	-115
		1000	0.55	167	1.79	57	0.181	56	0.35	-112
		1500	0.54	150	1.27	42	0.242	57	0.43	-122
	25	100	0.48	-129	17.61	112	0.041	51	0.47	-85
		300	0.55	-169	6.38	89	0.076	57	0.30	-125
		500	0.54	-176	3.97	77	0.111	62	0.27	-138
		700	0.50	172	2.94	71	0.114	61	0.30	-143
		1000	0.53	162	2.08	61	0.198	60	0.32	-135
		1500	0.50	146	1.50	47	0.267	57	0.37	-140
	50	100	0.47	-144	19.34	107	0.035	56	0.42	-100
		300	0.55	-173	6.72	87	0.073	63	0.31	-138
		500	0.53	-179	4.17	77	0.112	66	0.29	-150
		700	0.50	168	3.10	71	0.147	64	0.33	-153
		1000	0.53	159	2.19	62	0.206	61	0.32	-146
		1500	0.50	143	1.59	49	0.277	58	0.36	-149
10	10	100	0.56	-92	14.67	123	0.047	50	0.63	-50
		300	0.53	-152	6.00	92	0.077	47	0.34	-73
		500	0.53	-165	3.74	78	0.100	53	0.29	-82
		700	0.49	-177	2.76	70	0.124	56	0.31	-93
		1000	0.52	170	1.96	57	0.166	58	0.38	-94
		1500	0.51	153	1.36	42	0.221	59	0.46	-108
	25	100	0.46	-117	19.10	115	0.036	53	0.49	-68
		300	0.50	-164	7.09	90	0.071	57	0.26	-99
		500	0.49	-172	4.39	78	0.102	62	0.23	-110
		700	0.45	175	3.25	71	0.133	61	0.25	-119
		1000	0.49	164	2.28	60	0.181	61	0.30	-112
		1500	0.47	148	1.61	46	0.246	59	0.37	-120
	50	100	0.42	-131	20.99	110	0.033	56	0.41	-79
		300	0.49	-169	7.46	88	0.069	62	0.24	-111
		500	0.48	-175	4.63	78	0.103	65	0.21	-123
		700	0.45	172	3.40	71	0.136	64	0.25	-129
		1000	0.48	162	2.39	61	0.188	62	0.29	-119
		1500	0.45	146	1.70	48	0.251	59	0.35	-126

7

BFW92A

CASE 317A-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

7

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	35	mAdc
Total Device Dissipation @ T_C = 105°C Derate above 105°C	P_D	180 4.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to 150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case(1)	$R_{\theta JC}$	250	°C/W

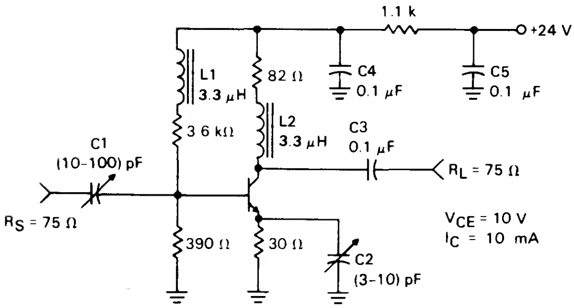
(1) Case temperature measured on collector lead immediately adjacent to body of package.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	50	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz, Emitter Guarded)	C_{cb}	—	0.5	1.0	pF
FUNCTIONAL PERFORMANCE					
Optimum Noise Figure (Tuned) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	NF_{opt}	—	2.7	—	dB
Noise Figure (Untuned, R_S = R_L = 50 Ω) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	NF	—	3.0	—	dB
Maximum Available Gain(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	MAG	—	16	—	dB
Insertion Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	$\|S_{21}\|^2$	—	14	—	dB

(2) $G_{max} = \dfrac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 — 30-900 MHz BROADBAND AMPLIFIER



C3, C4, C5 — 0.1 μF Chip Capacitor
L1, L2 — 3.3 μH Molded Inductor

All Resistors 1/4 W, 20%

FIGURE 2 — BROADBAND GAIN (Circuit Figure 1)

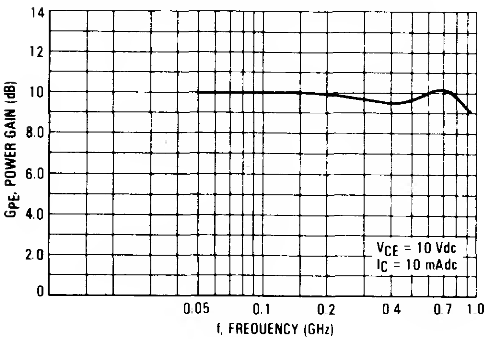


FIGURE 3 — 2nd AND 3rd ORDER INTERCEPT POINTS

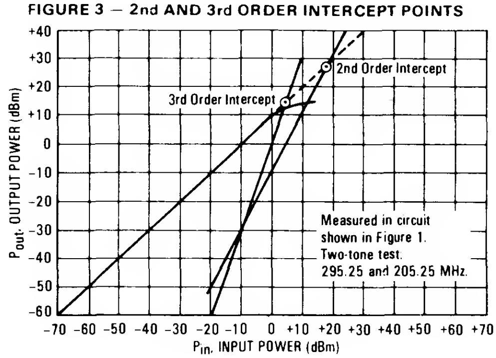


FIGURE 4 — MAXIMUM AVAILABLE GAIN versus FREQUENCY

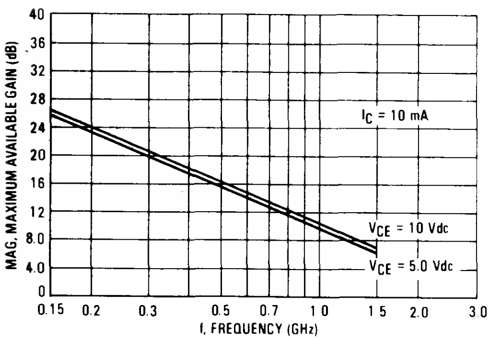


FIGURE 5 — $|S_{21}|^2$ versus FREQUENCY

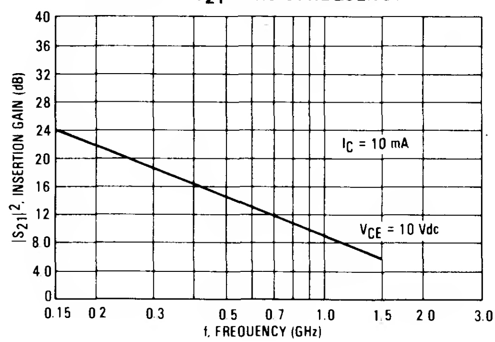


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FIGURE 6 — MAXIMUM AVAILABLE GAIN versus COLLECTOR CURRENT

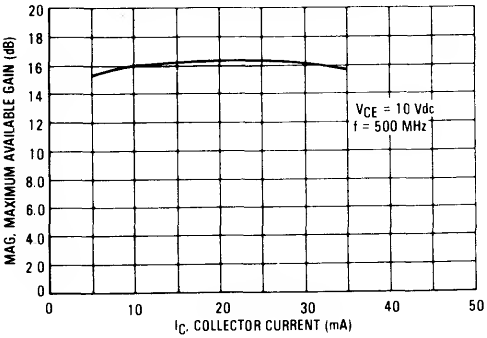

FIGURE 7 — GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

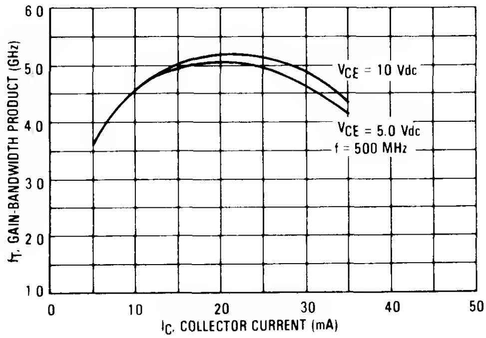

FIGURE 8 — NOISE FIGURE versus COLLECTOR CURRENT

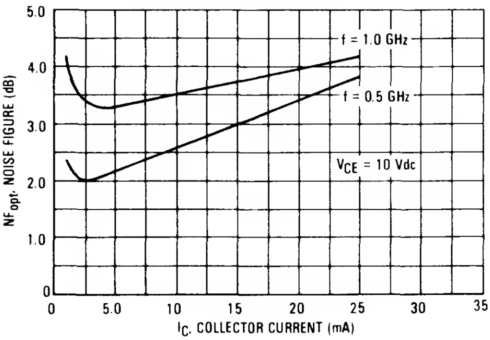

FIGURE 9 — NOISE FIGURE versus COLLECTOR CURRENT Untuned, $R_S = R_L = 50\ \Omega$

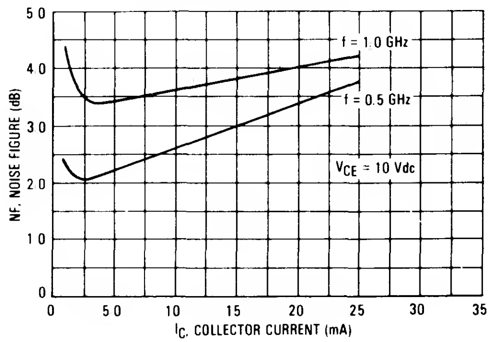

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FIGURE 10 — NOISE FIGURE versus FREQUENCY

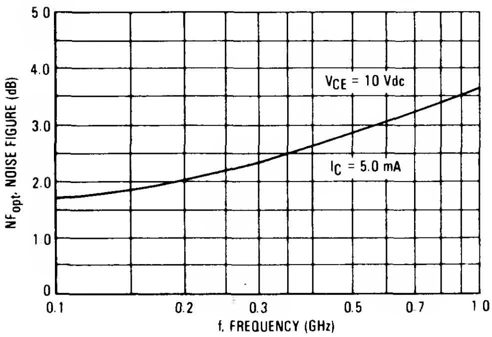


FIGURE 11 — NOISE FIGURE versus FREQUENCY Untuned $R_S = R_L = 50\ \Omega$

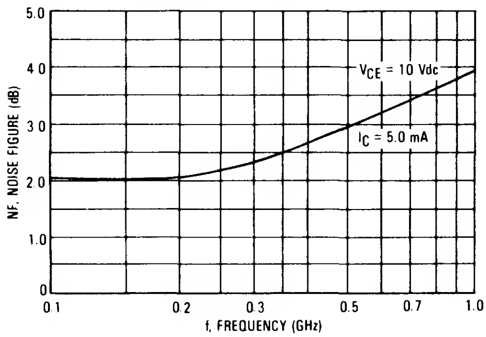


FIGURE 12 — C_{ib} INPUT CAPACITANCE versus EMITTER BASE VOLTAGE

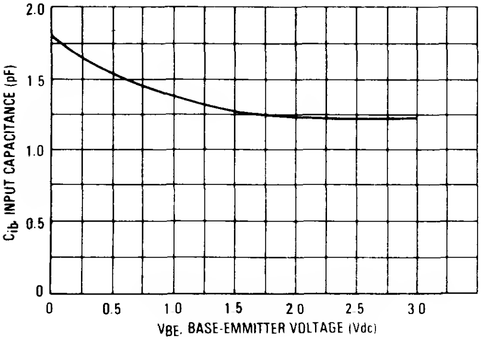
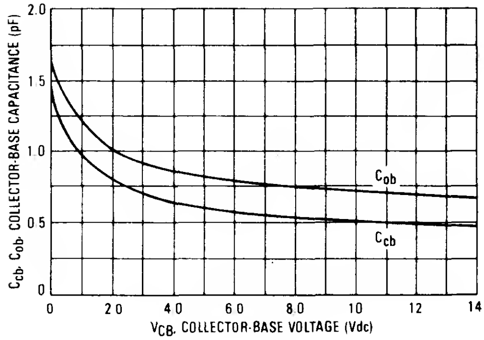
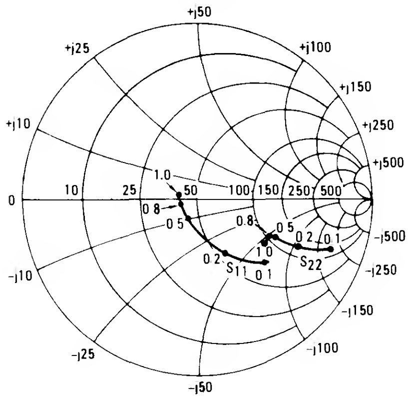


FIGURE 13 — COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE



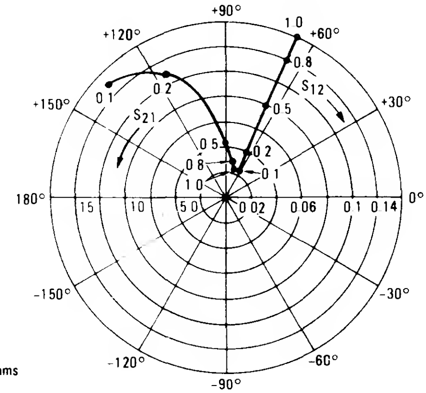
BFW92A COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 10 mA)



Coordinates in Ohms

FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 10 mA)



BFW92A COMMON-EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
5.0	5.0	100	0.71	-33	11.2	145	0.031	69	0.87	-18
		200	0.49	-60	8.6	122	0.052	62	0.70	-26
		500	0.21	-119	4.5	92	0.094	61	0.48	-30
		800	0.17	-161	3.0	78	0.137	60	0.44	-36
		1000	0.16	176	2.5	71	0.164	60	0.44	-40
	10	100	0.52	-46	16.6	135	0.027	67	0.78	-23
		200	0.31	-75	11.2	113	0.044	65	0.58	-29
		500	0.14	-150	5.2	88	0.089	67	0.40	-29
		800	0.15	173	3.3	76	0.135	65	0.37	-34
		1000	0.16	154	2.8	70	0.164	64	0.37	-38
	15	100	0.40	-55	19.7	129	0.025	69	0.72	-26
		200	0.22	-88	12.1	109	0.041	68	0.52	-29
		500	0.14	-170	5.4	86	0.087	70	0.36	-27
		800	0.16	161	3.5	76	0.134	68	0.34	-33
		1000	0.17	145	2.9	69	0.164	66	0.35	-37
	20	100	0.33	-62	21.1	125	0.023	69	0.68	-27
		200	0.18	-99	12.5	106	0.039	69	0.49	-28
		500	0.14	178	5.5	85	0.086	72	0.35	-26
		800	0.17	155	3.5	75	0.133	69	0.33	-32
		1000	0.18	142	2.9	69	0.164	67	0.34	-37
	25	100	0.27	-69	21.9	122	0.022	70	0.65	-27
		200	0.15	-111	12.7	104	0.038	71	0.47	-27
		500	0.16	172	5.5	85	0.085	73	0.35	-25
		800	0.19	153	3.5	75	0.132	70	0.33	-31
		1000	0.20	140	2.9	69	0.163	68	0.33	-36
10	5.0	100	0.73	-30	11.1	146	0.026	71	0.90	-14
		200	0.53	-52	8.8	124	0.044	63	0.75	-21
		500	0.21	-98	4.7	94	0.082	62	0.57	-25
		800	0.14	-136	3.1	80	0.120	62	0.53	-30
		1000	0.11	-161	2.6	73	0.143	62	0.53	-34
	10	100	0.57	-39	16.7	137	0.023	70	0.82	-18
		200	0.35	-62	11.5	115	0.038	66	0.65	-23
		500	0.12	-117	5.4	89	0.078	69	0.50	-23
		800	0.09	-163	3.5	78	0.118	67	0.47	-28
		1000	0.09	168	2.9	71	0.144	66	0.48	-32
	15	100	0.46	-46	19.9	130	0.021	70	0.77	-20
		200	0.26	-68	12.6	110	0.035	68	0.60	-22
		500	0.09	-137	5.6	87	0.076	71	0.47	-21
		800	0.09	177	3.7	77	0.117	69	0.45	-27
		1000	0.10	153	3.0	71	0.143	68	0.46	-31
	20	100	0.39	-50	21.5	126	0.020	70	0.74	-21
		200	0.21	-73	13.0	107	0.034	71	0.58	-21
		500	0.08	-154	5.7	86	0.075	72	0.46	-20
		800	0.10	168	3.7	76	0.117	70	0.45	-27
		1000	0.11	148	3.0	71	0.142	69	0.45	-31
	25	100	0.34	-54	22.3	123	0.019	70	0.71	-20
		200	0.17	-79	13.0	105	0.033	71	0.57	-20
		500	0.08	-166	5.7	86	0.075	73	0.47	-19
		800	0.11	162	3.7	76	0.116	70	0.45	-26
		1000	0.13	144	3.0	70	0.141	69	0.46	-30

7

BFX89
BFY90

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Continuous Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 200 1.14	 mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 25 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 25 20	 — —	 150 125	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) (I_C = 2.0 mA, V_{CE} = 5.0 Vdc, f = 500 MHz) (I_C = 25 mA, V_{CE} = 5.0 Vdc, f = 500 MHz)	 BFX89 BFY90 BFX89 BFY90	f_T	 — 1.0 — 1.3	 1.0 — 1.1 —	 — — — —	GHz
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	 BFY90	C_{ibo}	—	—	2.0	pF
Collector-Base Capacitance(2) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	 BFX89 BFY90	C_{cb}	 — —	 0.85 0.85	 1.7 1.5	pF
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain(1) (V_{CE} = 10 Vdc, I_C = 8.0 mA, f = 200 MHz)	 BFX89 BFY90	G_{pe}	 19 —	 — 21	 — —	dB
Spot Noise Figure (R_S = Optimum)(1) (V_{CE} = 5.0 Vdc, I_C = 2.0 mA, f = 500 MHz)	 BFX89 BFY90	NF	 — —	 2.5 2.5	 6.5 5.0	dB

(1) Pin 4 is grounded.
(2) Pin 4 is not grounded.

FIGURE 1 — POWER GAIN versus FREQUENCY

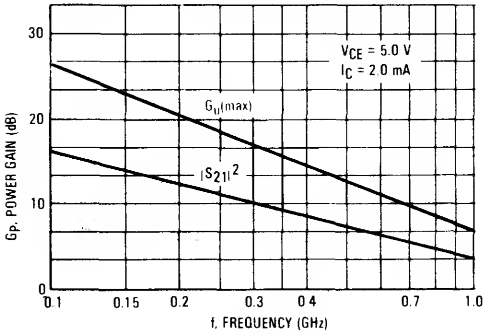


FIGURE 2 — POWER GAIN versus COLLECTOR CURRENT

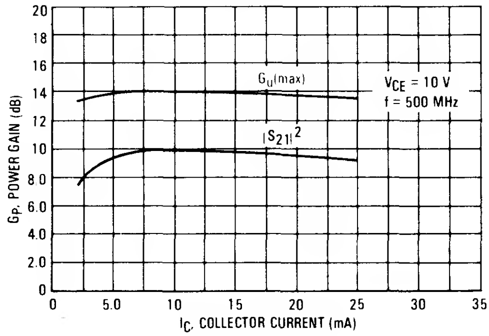


FIGURE 3 — NOISE FIGURE versus FREQUENCY

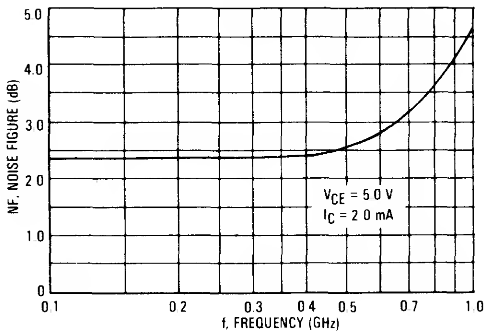


FIGURE 4 — NOISE FIGURE versus COLLECTOR CURRENT

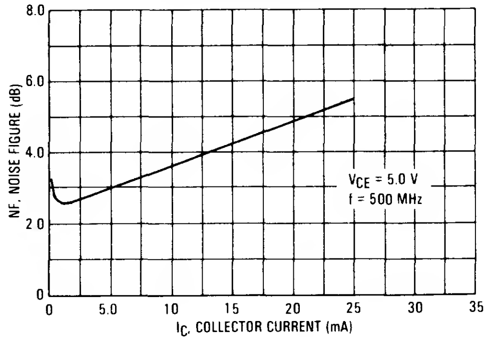


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

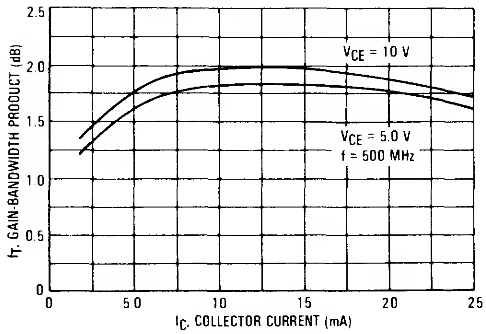
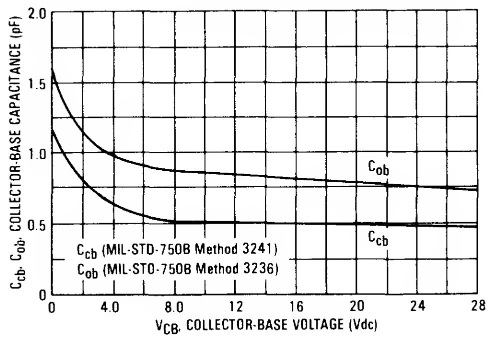
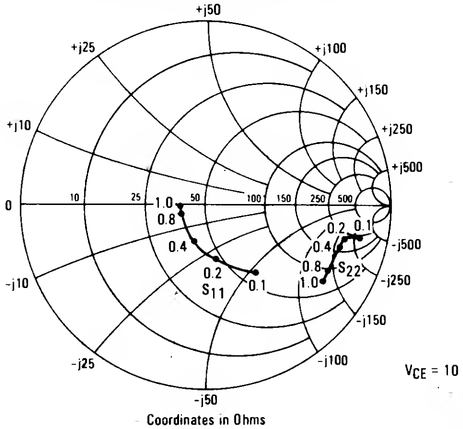


FIGURE 6 — OUTPUT CAPACITANCE versus VOLTAGE



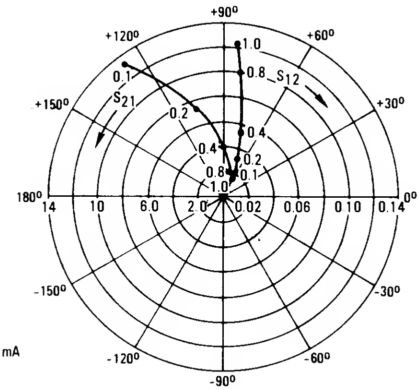
COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 — INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY



Coordinates in Ohms

FIGURE 8 — FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



V_{CE} = 10 V, I_C = 10 mA

S — PARAMETERS

V_{CE} (Volts)	I_C (mA)	Frequency (MHz)	S_{11} $\lvert S_{11}\rvert$	S_{11} $\angle\phi$	S_{21} $\lvert S_{21}\rvert$	S_{21} $\angle\phi$	S_{12} $\lvert S_{12}\rvert$	S_{12} $\angle\phi$	S_{22} $\lvert S_{22}\rvert$	S_{22} $\angle\phi$
5.0	2.0	100	0.81	-37	5.76	148	0.031	72	0.95	-11
		200	0.64	-66	4.56	127	0.050	63	0.87	-17
		400	0.41	-105	2.91	102	0.071	62	0.79	-23
		800	0.26	-157	1.63	77	0.105	74	0.75	-34
		1000	0.23	179	1.38	68	0.129	80	0.74	-41
	5.0	100	0.60	-54	9.73	133	0.026	68	0.87	-13
		200	0.41	-84	6.33	112	0.040	66	0.78	-17
		400	0.26	-121	3.54	92	0.064	72	0.73	-21
		800	0.19	-169	1.89	72	0.112	80	0.72	-31
		1000	0.17	168	1.59	64	0.140	82	0.71	-39
	10	100	0.71	-66	12.13	122	0.022	70	0.81	-14
		200	0.28	-96	7.11	104	0.036	71	0.73	-15
		400	0.19	-133	3.85	88	0.064	77	0.70	-19
		800	0.18	-178	2.00	69	0.115	83	0.71	-30
		1000	0.17	160	1.66	61	0.143	84	0.70	-37
	25	100	0.26	-88	12.79	112	0.019	73	0.76	-13
		200	0.20	-122	7.04	97	0.034	76	0.71	-13
		400	0.20	-156	3.68	83	0.062	81	0.70	-18
		800	0.23	165	1.88	65	0.114	86	0.71	-30
		1000	0.24	146	1.56	58	0.145	88	0.70	-38
10	2.0	100	0.83	-34	5.82	150	0.025	73	0.96	-9
		200	0.66	-61	4.60	129	0.042	65	0.89	-15
		400	0.42	-97	2.98	104	0.059	64	0.83	-20
		800	0.25	-147	1.69	79	0.088	77	0.80	-31
		1000	0.20	-172	1.42	70	0.108	82	0.79	-38
	5.0	100	0.63	-48	9.94	135	0.021	70	0.90	-11
		200	0.43	-76	6.54	114	0.034	68	0.82	-15
		400	0.26	-108	3.72	94	0.054	73	0.77	-19
		800	0.16	-155	1.98	74	0.095	83	0.77	-24
		1000	0.14	180	1.65	66	0.119	85	0.76	-36
	10	100	0.47	-57	12.42	125	0.019	70	0.85	-12
		200	0.30	-83	7.43	106	0.031	72	0.78	-14
		400	0.19	-113	4.04	90	0.054	78	0.75	-18
		800	0.14	-160	2.09	71	0.098	84	0.75	-28
		1000	0.13	173	1.73	64	0.121	86	0.75	-35
	25	100	0.32	-71	13.05	114	0.017	72	0.81	-11
		200	0.21	-99	7.27	99	0.029	76	0.77	-12
		400	0.16	-135	3.81	85	0.052	81	0.76	-16
		800	0.17	177	1.96	68	0.096	87	0.76	-28
		1000	0.18	154	1.62	61	0.120	89	0.76	-35

MD4957

CASE 654-02, STYLE 1
TO-78

DUAL
HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current	I_C	30		mAdc
		One Side	**Both Sides**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.15	400 2.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	1000	1500	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	0.4	0.8	pF
Small Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	—	200	—
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_{b'}C_c$	—	4.0	8.0	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz) (Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 GHz)	NF	 — —	 2.6 5.0	 — —	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz) (Figure 1) (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, R_S = 50 ohms, f = 1.0 GHz)	G_{pe}	 — —	 18 13	 — —	dB

TYPICAL NOISE FIGURE vs. FREQUENCY

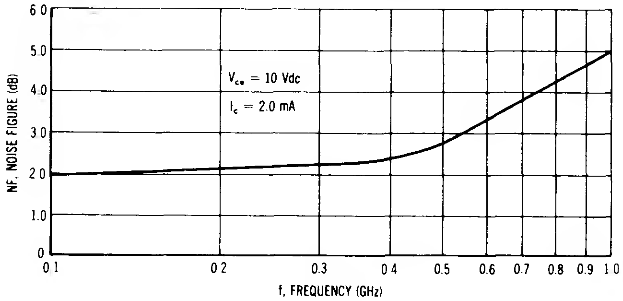
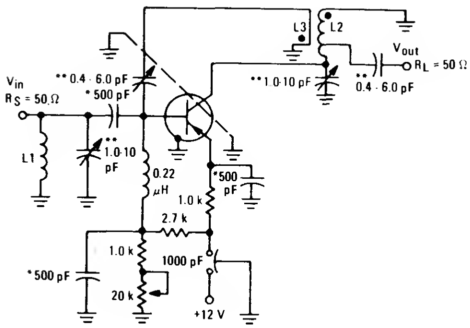


FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT



* Button type capacitors
** Variable air piston type capacitors

1. L1 - silver plated brass bar, 1.0 in. lg by 0.25 in od.
2. L2 - silver plated brass bar, 1.5 in. lg by 0.25 in od. Tap is 0.25 in. from collector
3. L3 - ½ turn of AWG No. 16 wire 0.25 in. from and parallel to L2.
4. The noise source is a hot-cold body (All type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

COMMON EMITTER Y PARAMETER VARIATIONS

Y PARAMETERS VS FREQUENCY

$V_{CE} = 10$ Vdc

$I_C = 2.0$ mA

FIGURE 2 — INPUT ADMITTANCE

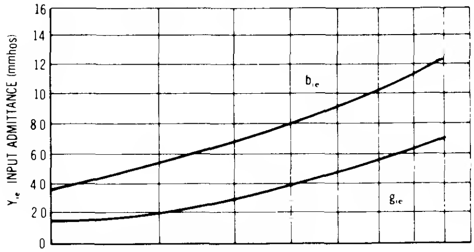


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

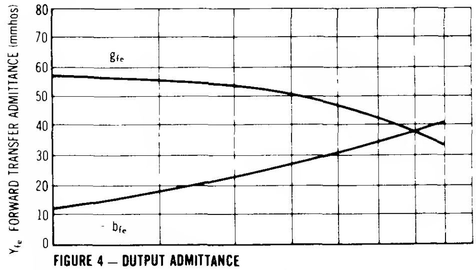


FIGURE 4 — OUTPUT ADMITTANCE

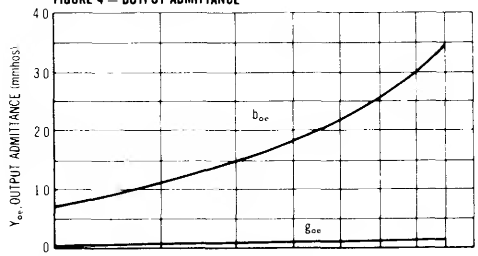
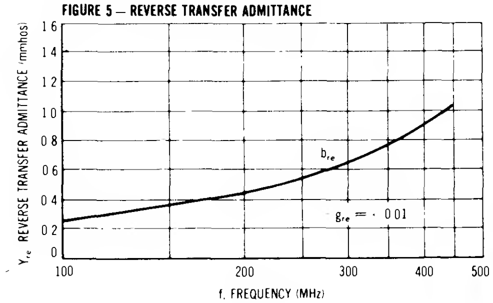


FIGURE 5 — REVERSE TRANSFER ADMITTANCE



Y PARAMETERS VS CURRENT

$V_{CE} = 10$ Vdc ——— $V_{CE} = 15$ Vdc — — —

f = 450 MHz

FIGURE 6 — INPUT ADMITTANCE

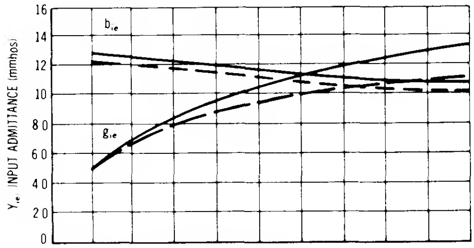


FIGURE 7 — FORWARD TRANSFER ADMITTANCE

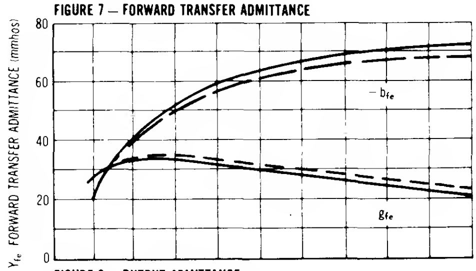


FIGURE 8 — OUTPUT ADMITTANCE

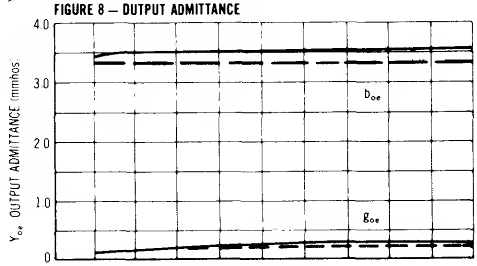
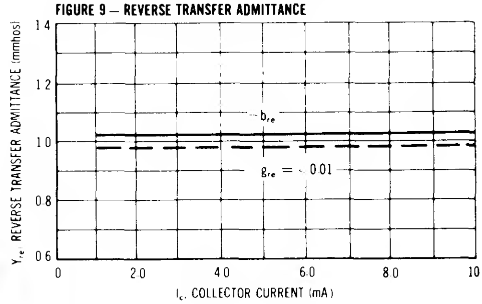


FIGURE 9 — REVERSE TRANSFER ADMITTANCE



COMMON BASE Y PARAMETER VARIATIONS

Y PARAMETERS versus FREQUENCY

$V_{CB} = 10$ Vdc

$I_C = 2.0$ mA

FIGURE 10 — INPUT ADMITTANCE

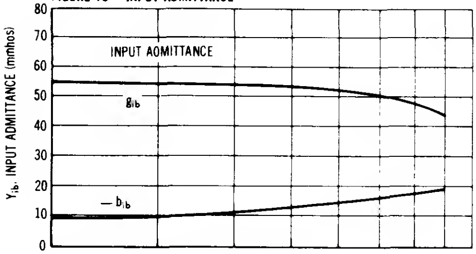


FIGURE 11 — FORWARD TRANSFER ADMITTANCE

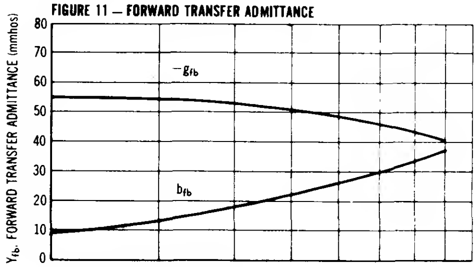


FIGURE 12 — OUTPUT ADMITTANCE

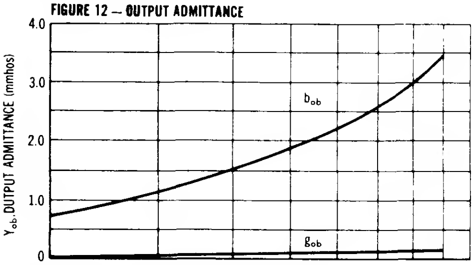
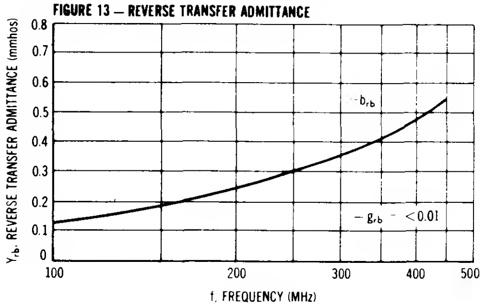


FIGURE 13 — REVERSE TRANSFER ADMITTANCE



Y PARAMETERS versus CURRENT

$V_{CB} = 10$ Vdc ——— $V_{CB} = 15$ Vdc — — —

f = 450 MHz

FIGURE 14 — INPUT ADMITTANCE

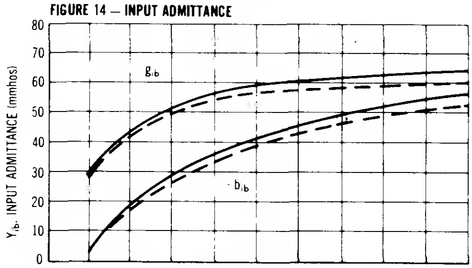


FIGURE 15 — FORWARD TRANSFER ADMITTANCE

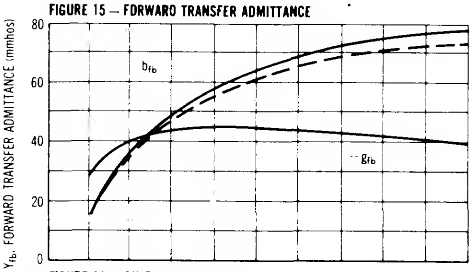


FIGURE 16 — OUTPUT ADMITTANCE

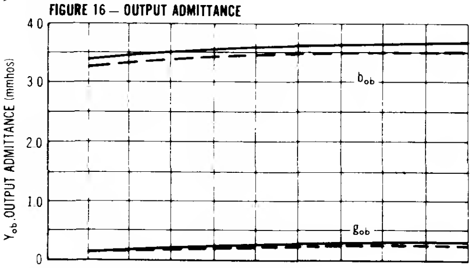
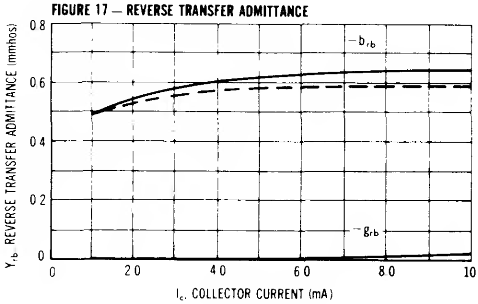


FIGURE 17 — REVERSE TRANSFER ADMITTANCE



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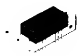
MHW590

CASE 714-02

WIDEBAND HYBRID AMPLIFIER



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	28	Vdc
Input Power	P_{in}	5.0	dBm
Operating Case Temperature Range	T_C	−20 to +90	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{DC} = 24 Vdc, Z_o = 50 Ω, T_C = 25°C. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	10	—	400	MHz
Power Gain	G_p	31.5	34	35.5	dB
Gain Flatness	F	—	—	±1.5	dB
Voltage Standing Wave Ratio, In/Out	VSWR				—
(f = 10–300 MHz)		—	1.5:1	—	
(f = 300–400 MHz)		—	2:1	—	
1 dB Compression	P1				mW
(f = 10 MHz)		—	800	—	
(f = 200 MHz)		700	800	—	
(f = 400 MHz)		—	300	—	
Reverse Isolation	P_{RI}	43	50	—	dB
2nd Harmonic (P_{out} = 10 mW)	d_{so}	—	−66	—	dB
Third Order Intercept	I_{TO}	—	43	—	dBm
Peak Envelope Power for −32 dB Distortion	PEP	—	500	—	mW
Noise Figure	NF				dB
(f = 60 MHz)		—	4.0	—	
(f = 300 MHz)		—	3.5	5.5	
DC Voltage	V_{DC}	—	24	28	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 – POWER GAIN AND RETURN LOSS versus FREQUENCY

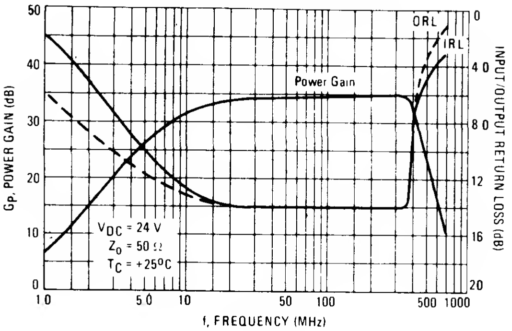


FIGURE 2 – POWER GAIN versus FREQUENCY

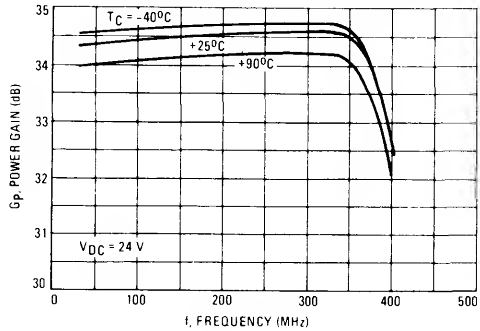


FIGURE 3 – POWER GAIN versus SUPPLY VOLTAGE

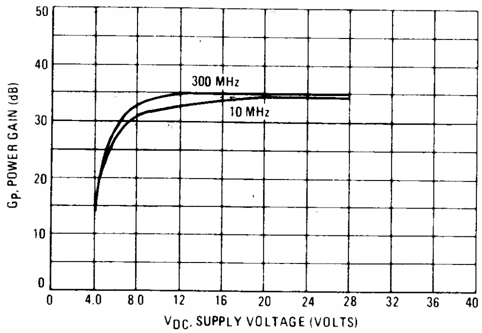


FIGURE 4 – NOISE FIGURE versus SUPPLY VOLTAGE

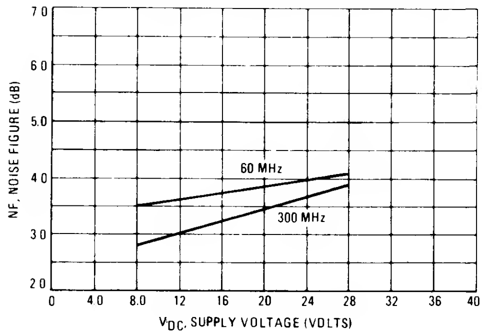


FIGURE 5 – OUTPUT POWER versus INPUT POWER

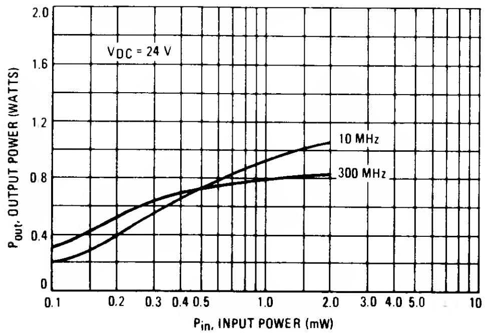


FIGURE 6 – OUTPUT POWER versus INPUT POWER

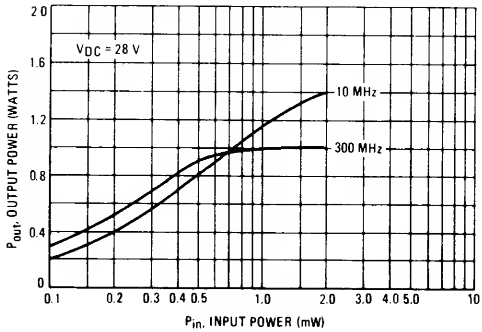


FIGURE 7 – INTERMODULATION DISTORTION – THIRD ORDER versus OUTPUT POWER

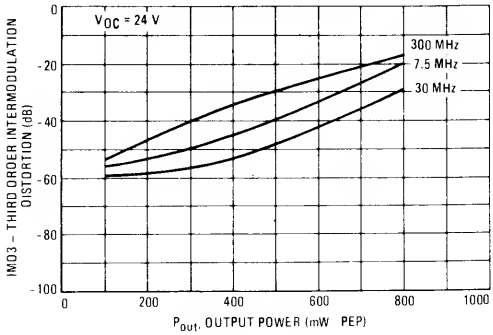


FIGURE 8 – INTERMODULATION DISTORTION – FIFTH ORDER versus OUTPUT POWER

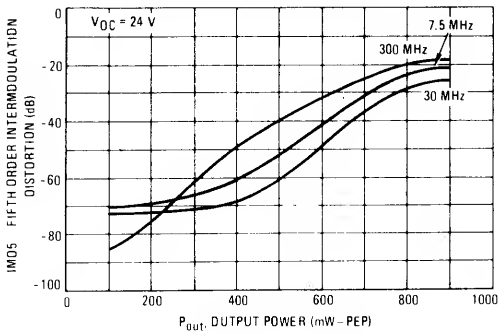


FIGURE 9 – INTERMODULATION DISTORTION – THIRD ORDER versus OUTPUT POWER

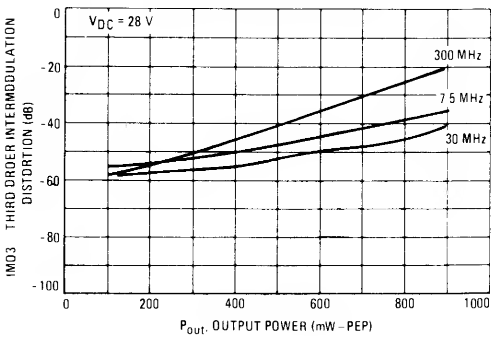


FIGURE 10 – INTERMODULATION DISTORTION – FIFTH ORDER versus OUTPUT POWER

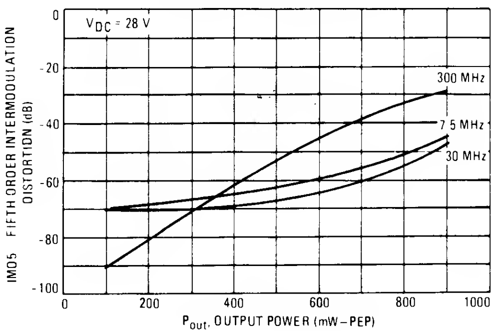
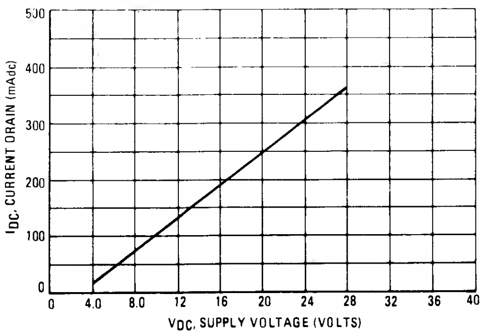


FIGURE 11 – DC CURRENT DRAIN versus SUPPLY VOLTAGE



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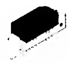
MHW591

CASE 714-02

WIDEBAND HYBRID AMPLIFIER



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	16	Vdc
Input Power	P_{in}	3.0	dBm
Operating Case Temperature Range	T_C	−20 to +90	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{DC} = 13.6 Vdc, Z_o = 50 Ω, T_C = 25°C. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	1.0	—	250	MHz
Power Gain	G_p	34.5	36.5	38	dB
Gain Flatness	F	—	—	±1.5	dB
Voltage Standing Wave Ratio, In/Out	VSWR				—
(f = 1.0–30 MHz)		—	1.5:1	—	
(f = 30–250 MHz)		—	2:1	—	
1 dB Compression	P1				mW
(f = 30 MHz)		650	800	—	
(f = 100 MHz)		—	700	—	
(f = 250 MHz)		—	250	—	
Peak Envelope Power	PEP				mW
(IMD3 = −30 dB, f = 30 MHz)		700	850	—	
(IMD3 = −30 dB, f = 100 MHz)		—	600	—	
(IMD3 = −30 dB, f = 250 MHz)		—	300	—	
Noise Figure	NF				dB
(f = 30 MHz)		—	3.7	5.0	
(f = 100 MHz)		—	3.7	—	
(f = 250 MHz)		—	4.5	—	
DC Voltage	V_{DC}	—	13.6	16	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 — POWER GAIN versus FREQUENCY

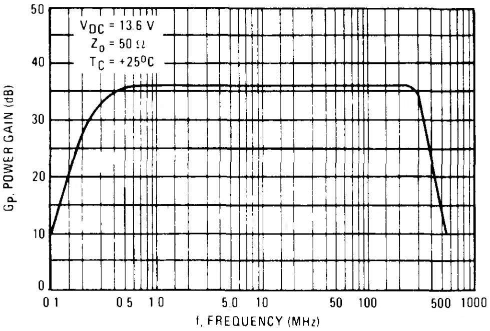


FIGURE 2 — POWER GAIN versus FREQUENCY

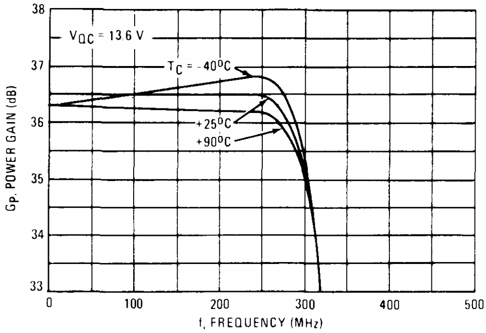


FIGURE 3 — POWER GAIN versus SUPPLY VOLTAGE

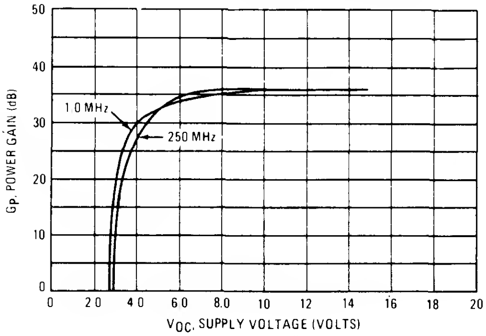


FIGURE 4 — NOISE FIGURE versus SUPPLY VOLTAGE

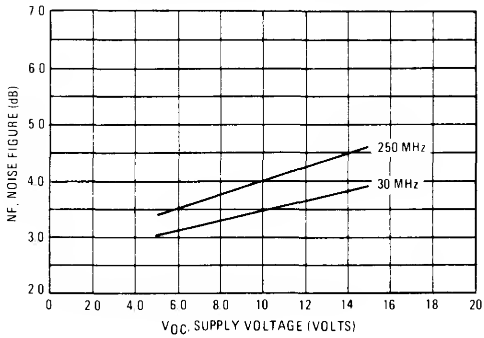


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FIGURE 5 — OUTPUT POWER versus INPUT POWER

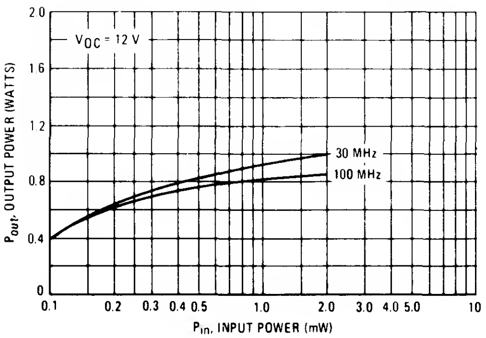


FIGURE 6 — OUTPUT POWER versus INPUT POWER

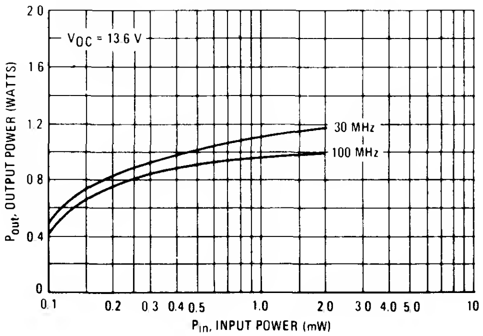


FIGURE 7 – INTERMODULATION DISTORTION versus OUTPUT POWER

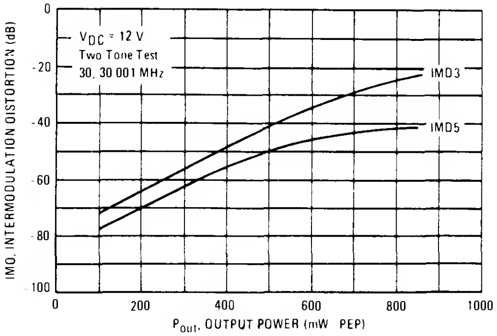


FIGURE 8 – INTERMODULATION DISTORTION versus OUTPUT POWER

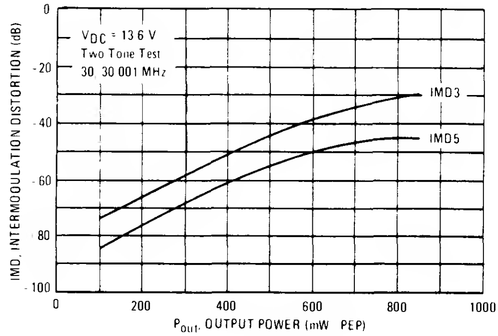
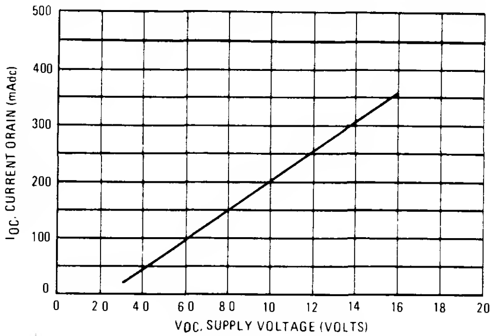


FIGURE 9 – DC CURRENT DRAIN versus SUPPLY VOLTAGE



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MHW592

CASE 714-02

WIDEBAND HYBRID AMPLIFIER

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	28	Vdc
Input Power	P_{in}	5.0	dBm
Operating Case Temperature Range	T_C	−20 to +90	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{DC} = 24 Vdc, Z_o = 50 Ω, T_C = 25°C. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	1.0	—	250	MHz
Power Gain	G_p	33.5	35	36.5	dB
Gain Flatness	F	—	—	±1.0	dB
Voltage Standing Wave Ratio, In/Out	VSWR				—
(f = 1.0–30 MHz)		—	1.5:1	—	
(f = 30–250 MHz)		—	2:1	—	
1 dB Compression	P1				mW
(f = 30 MHz)		750	900	—	
(f = 100 MHz)		—	900	—	
(f = 250 MHz)		—	750	—	
Peak Envelope Power	PEP				mW
(IMD3 = −30 dB, f = 30 MHz)		700	850	—	
(IMD3 = −30 dB, f = 100 MHz)		—	850	—	
(IMD3 = −30 dB, f = 250 MHz)		—	600	—	
Noise Figure	NF				dB
(f = 30 MHz)		—	3.6	5.0	
(f = 100 MHz)		—	3.7	—	
(f = 250 MHz)		—	3.9	—	
DC Voltage	V_{DC}	—	24	28	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 — POWER GAIN versus FREQUENCY

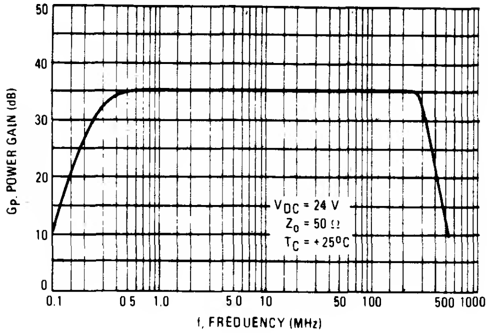

FIGURE 2 — POWER GAIN versus FREQUENCY

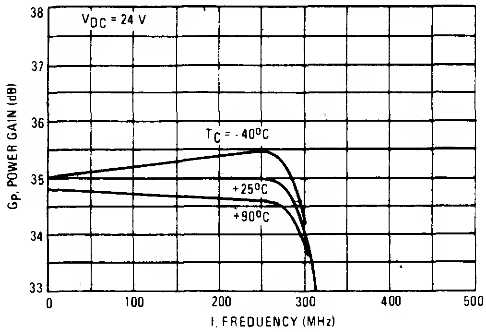

FIGURE 3 — POWER GAIN versus SUPPLY VOLTAGE

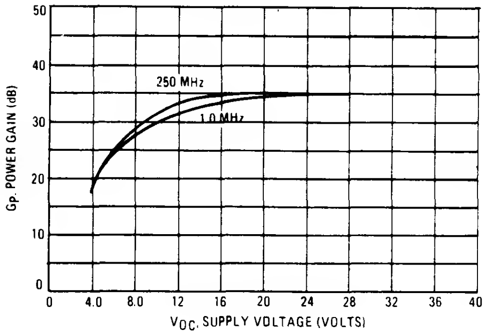

FIGURE 4 — NOISE FIGURE versus SUPPLY VOLTAGE

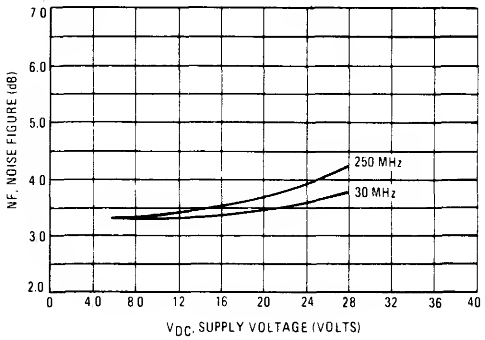

FIGURE 5 — OUTPUT POWER versus INPUT POWER

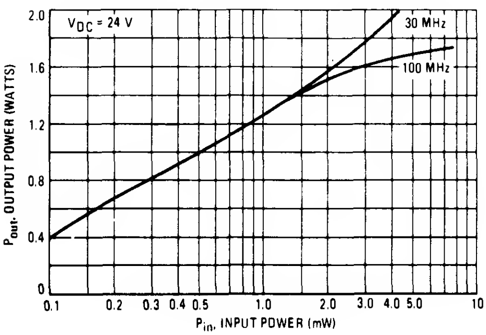

FIGURE 6 — OUTPUT POWER versus INPUT POWER

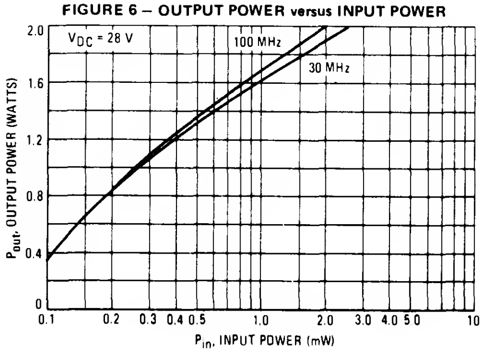

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FIGURE 7 — INTERMODULATION DISTORTION versus OUTPUT POWER

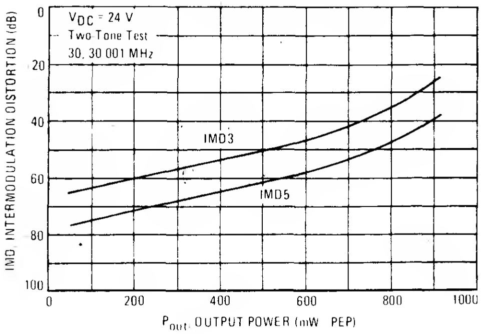


FIGURE 8 — INTERMODULATION DISTORTION versus OUTPUT POWER

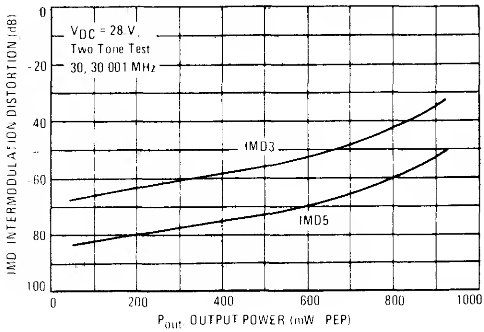
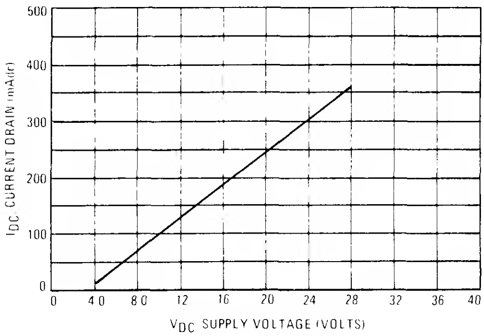


FIGURE 9 — DC CURRENT DRAIN versus SUPPLY VOLTAGE



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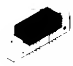
MHW593

CASE 714-02

WIDEBAND HYBRID AMPLIFIER



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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	16	Vdc
Input Power	P_{in}	3.0	dBm
Operating Case Temperature Range	T_C	−20 to +90	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{DC} = 13.6 Vdc, Z_o = 50 Ω, T_C = 25°C. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	10	—	400	MHz
Power Gain	G_p	33	34.5	36	dB
Gain Flatness	F	—	—	±1.0	dB
Voltage Standing Wave Ratio, In/Out (f = 10–300 MHz) (f = 300–400 MHz)	VSWR	 — —	 1.5:1 2:1	 — —	—
1 dB Compression (f = 10 MHz) (f = 200 MHz) (f = 400 MHz)	P1	 — 500 —	 600 600 200	 — — —	mW
Reverse Isolation	P_{RI}	45	50	—	dB
2nd Harmonic (P_{out} = 10 mW)	d_{so}	—	−55	—	dB
Third Order Intercept	I_{TO}	—	38	—	dBm
Peak Envelope Power for −32 dB Distortion	PEP	—	300	—	mW
Noise Figure (f = 60 MHz) (f = 300 MHz)	NF	 — —	 3.7 4.0	 — 5.5	dB
DC Voltage	V_{DC}	—	13.6	16	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 — POWER GAIN AND RETURN LOSS versus FREQUENCY

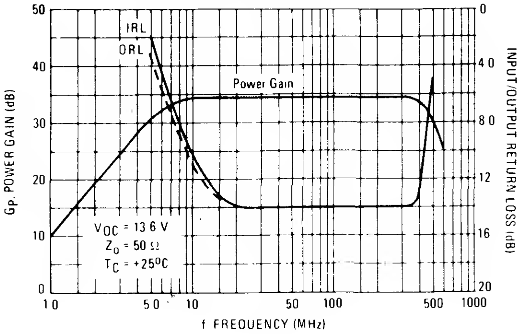

FIGURE 2 — POWER GAIN versus FREQUENCY

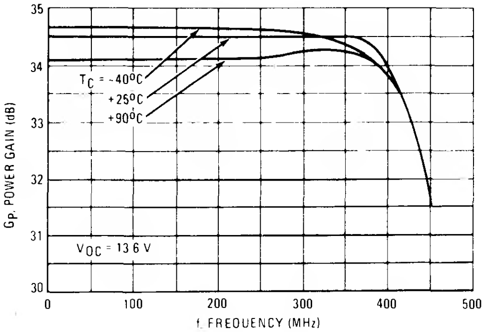

FIGURE 3 — POWER GAIN versus SUPPLY VOLTAGE

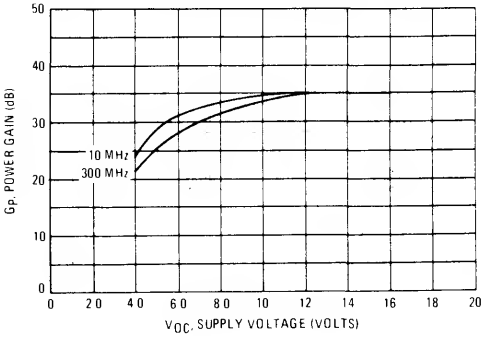

FIGURE 4 — NOISE FIGURE versus SUPPLY VOLTAGE

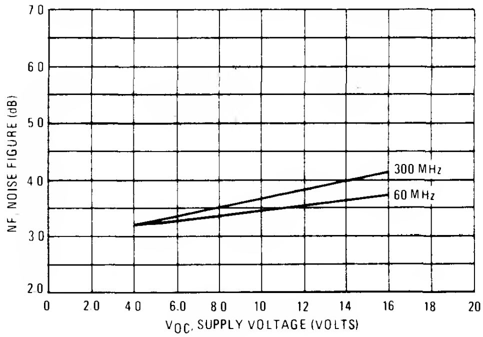

FIGURE 5 — OUTPUT POWER versus INPUT POWER

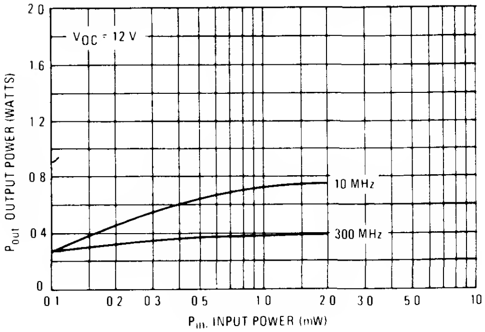

FIGURE 6 — OUTPUT POWER versus INPUT POWER

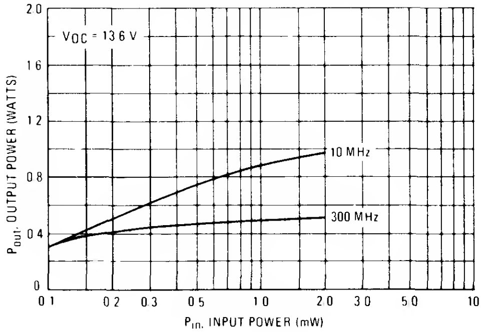

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FIGURE 7 – INTERMODULATION DISTORTION – THIRD ORDER versus OUTPUT POWER

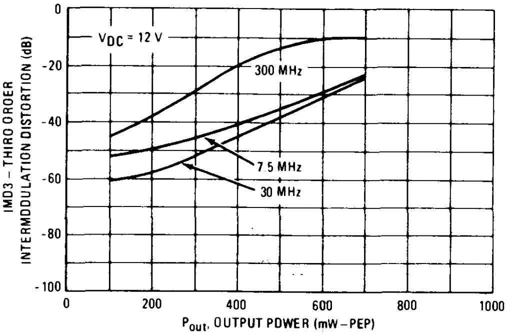


FIGURE 8 – INTERMODULATION DISTORTION – FIFTH ORDER versus OUTPUT POWER

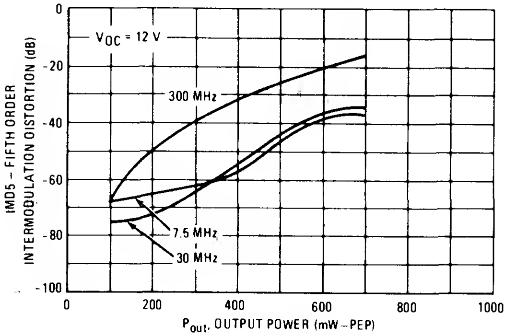


FIGURE 9 – INTERMODULATION DISTORTION – THIRD ORDER versus OUTPUT POWER

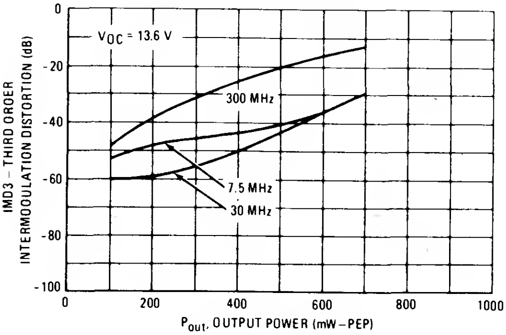


FIGURE 10 – INTERMODULATION DISTORTION – FIFTH ORDER versus OUTPUT POWER

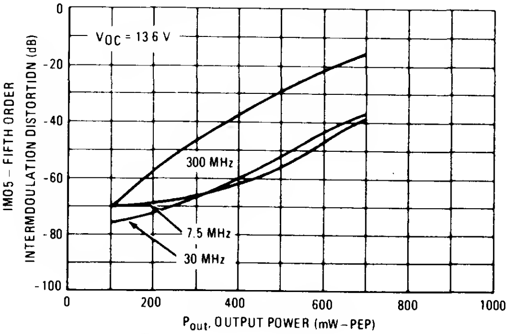
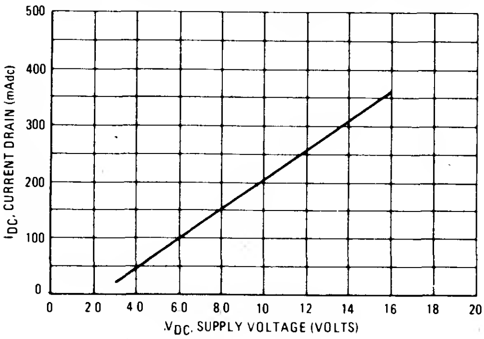


FIGURE 11 – DC CURRENT DRAIN versus SUPPLY VOLTAGE



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MM4018

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 5.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0)	I_{CES}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	—	900	—	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	3.5	—	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 50 mW, V_{CC} = 12.5 Vdc, f = 175 MHz)	P_{out}	0.5	—	—	Watt
Collector Efficiency (Figure 1) (P_{in} = 50 mW, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	45	55	—	%

FIGURE 1 – 175 MHz OUTPUT POWER TEST CIRCUIT

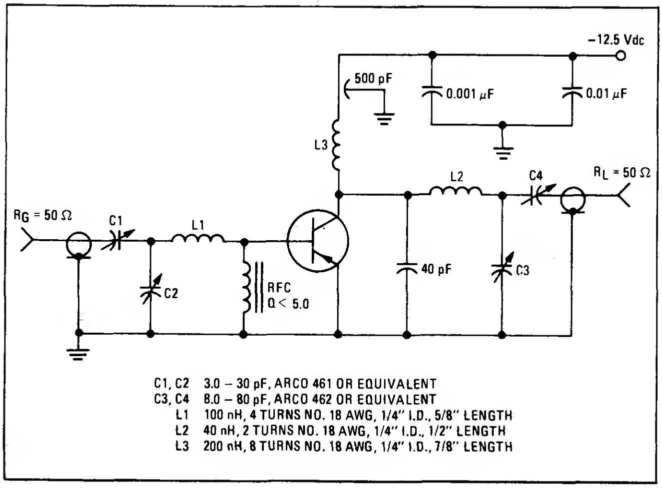


FIGURE 2 – POWER OUTPUT versus POWER INPUT

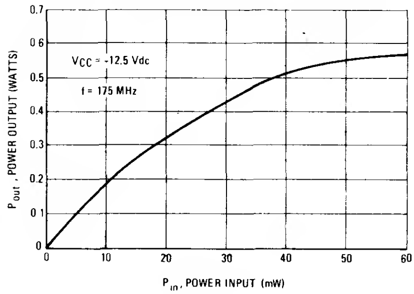


FIGURE 3 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

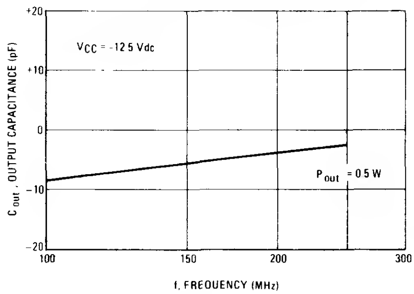


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

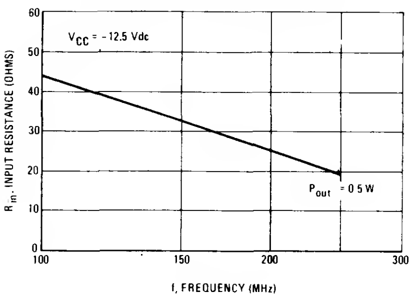
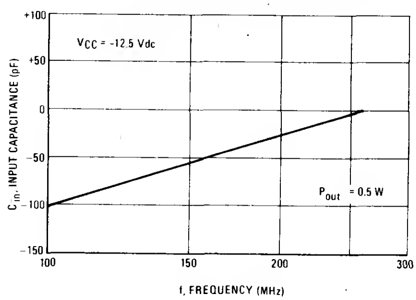


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



MM4019

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON

Refer to 2N5160 for graphs.

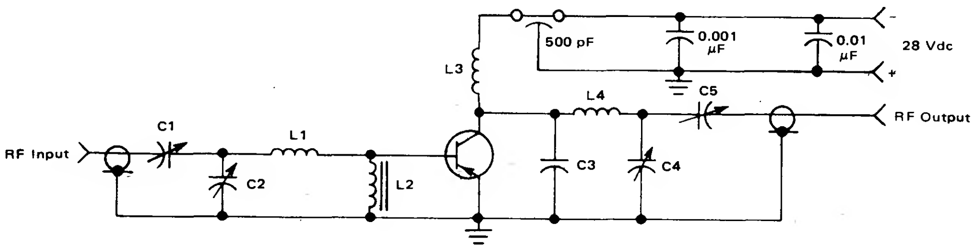
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 mAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 Adc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	—	—	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—	—
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	—	750	—	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	7.5	—	pF
FUNCTIONAL TEST					
Power Output (P_{in} = 0.5 W, V_{CC} = 28 Vdc, f = 400 MHz)	P_{out}	—	2.0	—	Watts
Collector Efficiency (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	η	50	—	—	%
Power Input (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	P_{in}	—	—	0.25	Watt

FIGURE 1 – 175 MHz TEST CIRCUIT



C1,C2	3.0-30 pF, ARCO 461 or equivalent.
C3	40 pF
C4,C5	5.0-80 pF, ARCO 462 or equivalent.
L1	80 nH, 3 Turns #18 AWG, 1/4" I.D., 1/4" Length
L2	Ferrite Choke, VK-200 Ferroxcube, Q < 5
L3	0.15 μH, RF Choke
L4	27 nH, 2 Turns #18 AWG, 1/4" I.D., 3/8" Length

MM4049
MRF534
MRF536

MRF534
CASE 22-03, STYLE 1
TO-206AA

MRF536
CASE 317-01, STYLE 2

MM4049
CASE 20-03, STYLE 2
TO-206AF

HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS		MM4049 Case 20-03 TO-206AF	MRF534 Case 22-03 TO-206AA	MRF536 Case 317-01 Macro-X	
Collector-Emitter Voltage	V_{CEO}	10	10	10	Vdc
Collector-Base Voltage	V_{CBO}	15	15	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	4.5	4.5	Vdc
Collector Current — Continuous	I_C	30	30	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	300 1.71	300 2.40	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	−65 to +200	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	10	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 25 mAdc, V_{CE} = 2.0 Vdc)		h_{FE}	20	—	200	—
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 5.0 Vdc, f = 500 MHz)	MRF534, MM4049 MRF536	f_T	4.0 5.0	— —	— —	GHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	—	1.3	pF
FUNCTIONAL TEST						
Maximum Available Gain (I_C = 15 mAdc, V_{CE} = 5.0 Vdc, f = 500 MHz) (I_C = 15 mAdc, V_{CE} = 5.0 Vdc, f = 500 MHz) (I_C = 15 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 GHz)	 MRF534 MM4049 MRF536	MAG	 10 11.5 8.5	 12 13 10	 — — —	dB

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FIGURE 1 — CURRENT GAIN — BANDWIDTH PRODUCT versus CURRENT

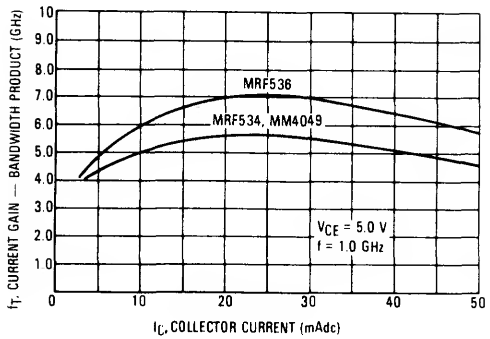


FIGURE 2 — MAXIMUM AVAILABLE GAIN versus COLLECTOR CURRENT

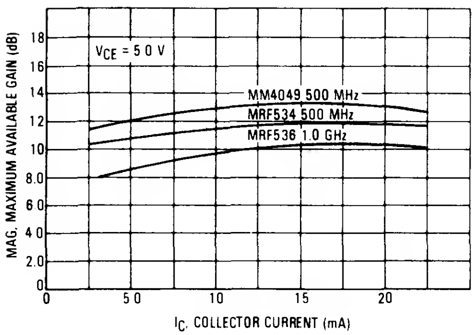
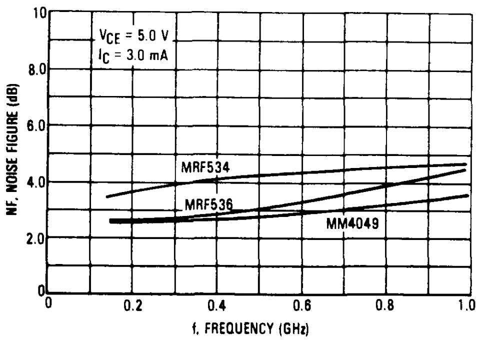


FIGURE 3 — NOISE FIGURE versus FREQUENCY



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MM4049 COMMON-EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
5.0	5.0	200	0.634	-31	6.37	120	0.060	69	0.711	-23
		400	0.469	-34	3.95	93	0.107	65	0.602	-30
		600	0.379	-40	2.90	77	0.147	62	0.587	-33
		800	0.368	-51	2.32	65	0.183	56	0.55	-36
		1000	0.381	-54	1.93	55	0.223	50	0.528	-44
	10	200	0.523	-29	7.79	112	0.056	72	0.632	-23
		400	0.418	-28	3.74	89	0.104	68	0.543	-29
		600	0.344	-34	3.20	74	0.146	65	0.542	-32
		800	0.345	-46	2.54	64	0.184	58	0.513	-34
		1000	0.366	-50	2.09	54	0.225	52	0.493	-42
	20	200	0.454	-25	8.43	106	0.065	73	0.584	-21
		400	0.390	-23	4.67	85	0.105	70	0.513	-27
		600	0.325	-30	3.31	72	0.148	66	0.620	-30
		800	0.327	-44	2.61	62	0.188	59	0.497	-32
		1000	0.351	-48	2.15	52	0.231	52	0.476	-41
10	5.0	200	0.731	-25	5.83	121	0.053	70	0.736	-18
		400	0.589	-30	3.65	95	0.096	67	0.654	-26
		600	0.502	-38	2.71	79	0.132	64	0.645	-29
		800	0.496	-49	2.21	68	0.164	57	0.612	-33
		1000	0.499	-54	1.83	58	0.198	51	0.592	-42
	10	200	0.643	-25	7.37	114	0.051	71	0.668	-18
		400	0.542	-27	4.28	90	0.094	69	0.060	-25
		600	0.466	-34	3.10	76	0.132	65	0.603	-28
		800	0.465	-46	2.49	66	0.166	59	0.577	-31
		1000	0.476	-51	2.05	57	0.202	53	0.557	-40
	20	200	0.57	-23	8.44	109	0.049	73	0.621	-18
		400	0.496	-24	4.73	88	0.093	71	0.562	-24
		600	0.427	-31	3.38	75	0.131	67	0.572	-27
		800	0.427	-43	2.69	66	0.165	60	0.551	-30
		1000	0.445	-47	2.21	57	0.203	54	0.532	-38

MRF534 COMMON-EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
5.0	5.0	200	0.734	-22	3.70	126	0.066	66	0.507	-39
		400	0.580	-28	2.56	108	0.116	65	0.409	-48
		600	0.444	-37	2.09	95	0.158	62	0.403	-52
		800	0.400	-47	1.80	86	0.195	56	0.364	-56
		1000	0.366	-47	1.55	79	0.234	51	0.348	-69
	10	200	0.645	-27	5.36	124	0.058	69	0.394	-43
		400	0.503	-33	3.44	106	0.109	71	0.316	-52
		600	0.376	-43	2.68	93	0.153	69	0.323	-52
		800	0.333	-54	2.24	84	0.192	65	0.290	-55
		1000	0.295	-54	1.91	77	0.233	61	0.276	-71
	20	200	0.586	-28	5.90	122	0.053	70	0.338	-52
		400	0.454	-34	3.73	105	0.099	73	0.259	-60
		600	0.329	-46	2.87	93	0.143	72	0.267	-58
		800	0.289	-59	2.38	85	0.181	68	0.240	-59
		1000	0.248	-58	2.04	77	0.221	65	0.235	-75
10	5.0	200	0.752	-21	4.28	125	0.066	70	0.550	-28
		400	0.624	-26	2.77	107	0.123	68	0.495	-38
		600	0.512	-34	2.19	94	0.168	65	0.503	-44
		800	0.476	-44	1.86	86	0.207	60	0.464	-51
		1000	0.447	-45	1.60	79	0.246	55	0.443	-64
	10	200	0.685	-24	5.47	123	0.060	71	0.442	-33
		400	0.553	-28	3.46	105	0.113	71	0.385	-42
		600	0.433	-37	2.68	93	0.156	68	0.397	-46
		800	0.391	-49	2.25	85	0.194	63	0.362	-51
		1000	0.359	-47	1.92	78	0.233	59	0.342	-65
	20	200	0.621	-26	6.38	121	0.055	71	0.372	-40
		400	0.488	-31	3.97	104	0.103	72	0.316	-48
		600	0.365	-41	3.04	93	0.145	70	0.332	-50
		800	0.323	-52	2.51	85	0.182	66	0.301	-54
		1000	0.290	-50	2.13	79	0.219	63	0.288	-68

MRF536 COMMON-EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
5.0	5.0	400	0.401	-74	5.38	108	0.09	54	0.49	-48
		800	0.181	-102	3.03	86	0.138	51	0.35	-64
		1200	0.136	-157	2.13	70	0.181	48	0.32	-70
		1600	0.151	175	1.68	59	0.21	45	0.27	-80
		2000	0.16	148	1.44	52	0.24	41	0.269	-100
	10	400	0.289	-94	6.58	103	0.076	56	0.379	-56
		800	0.14	-137	3.55	84	0.122	55	0.266	-73
		1200	0.174	169	2.46	70	0.165	53	0.238	-77
		1600	0.196	154	1.93	60	0.196	50	0.198	-87
		2000	0.227	130	1.65	51	0.230	46	0.202	-110
	20	400	0.233	-118	7.28	99	0.066	60	0.296	-65
		800	0.163	-169	3.88	82	0.110	59	0.204	-84
		1200	0.233	156	2.65	69	0.153	57	0.179	-84
		1600	0.253	144	2.06	59	0.186	55	0.143	-96
		2000	0.290	123	1.75	50	0.220	51	0.160	-121
10	5.0	400	0.478	-54	5.14	109	0.086	58	0.535	-39
		800	0.279	-66	2.90	88	0.141	53	0.420	-55
		1200	0.166	-97	2.08	73	0.184	48	0.388	-62
		1600	0.151	-123	1.67	64	0.209	44	0.33	-72
		2000	0.110	-158	1.44	55	0.243	39	0.313	-90
	10	400	0.356	-67	6.59	105	0.075	59	0.418	-47
		800	0.182	-84	3.59	86	0.124	56	0.311	-62
		1200	0.119	-141	2.53	73	0.166	52	0.284	-67
		1600	0.131	-166	2.00	62	0.193	49	0.230	-76
		2000	0.135	154	1.72	55	0.226	45	0.222	-98
	20	400	0.26	-85	7.66	101	0.066	61	0.328	-53
		800	0.124	122	4.09	84	0.111	59	0.236	-69
		1200	0.148	172	2.83	72	0.152	56	0.216	-71
		1600	0.172	158	2.22	62	0.182	54	0.172	-80
		2000	0.201	130	1.88	54	0.214	50	0.171	-104

7

MM8000
MM8001
MM8002

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

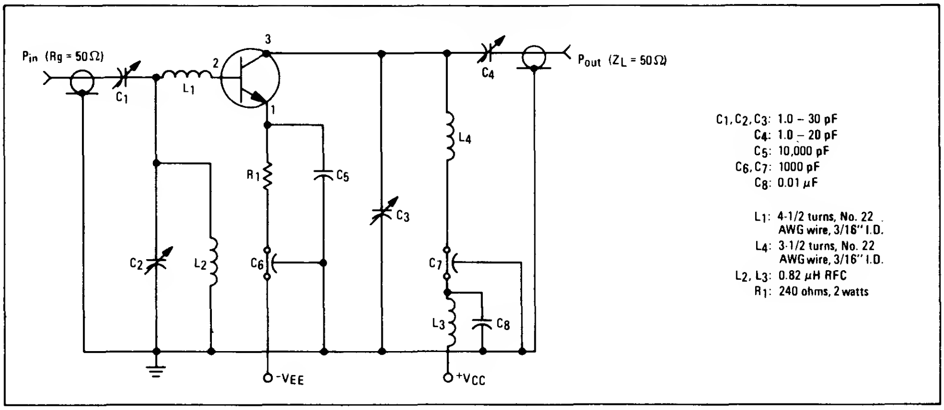
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{CEO(sus)}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)		I_{CEO}	—	—	20	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)		h_{FE}	30	—	—	—
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000 MM8001 MM8002		550 700 1000	— — —	— — —	
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000 MM8001 MM8002		700 900 1200	— — —	— — —	
(I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000 MM8001 MM8002		700 900 1000	— — —	— — —	
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	—	3.5	pF
Noise Figure (Figure 1) (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		NF	—	2.7	—	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		G_{pe}	—	11.4	—	dB

FIGURE 1 – 200 MHz TEST CIRCUIT



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MM8009

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	100	μAdc
Collector Cutoff Current (V_{CE} = 35 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	1000	—	—	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	2.3	3.0	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	P_{out}	0.9	—	—	Watt
Power Output (Oscillator) (Figure 2) (V_{CE} = 20 Vdc, V_{EB} = 1.5 Vdc, f = 1.68 GHz) (Minimum Efficiency = 15%)	P_{out}	—	0.3	—	Watt
Collector Efficiency (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	η	35	—	—	%

FIGURE 1 – 1.0 GHz POWER AMPLIFIER TEST CIRCUIT

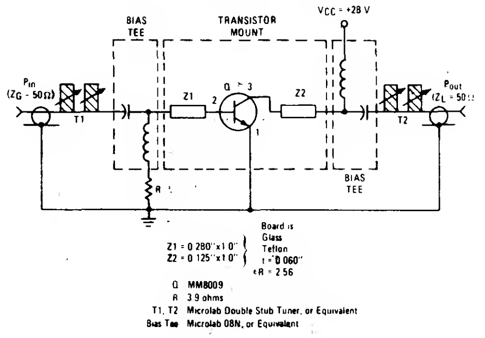

FIGURE 2 – 1.68 GHz POWER OSCILLATOR TEST CIRCUIT

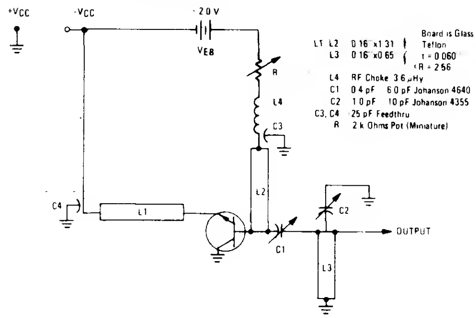

FIGURE 3 – POWER OUTPUT versus POWER INPUT

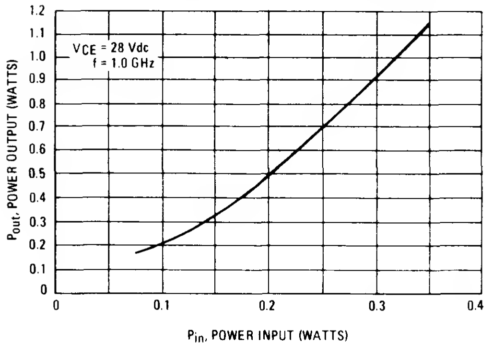

FIGURE 4 – POWER OUTPUT versus FREQUENCY

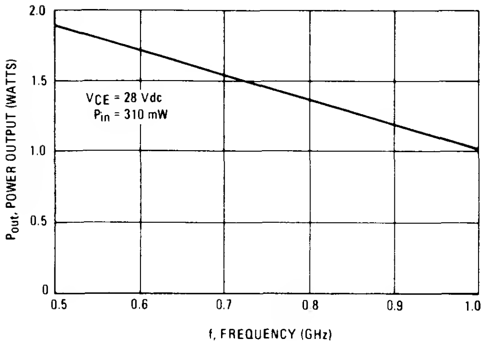

FIGURE 5 – POWER OUTPUT versus VOLTAGE

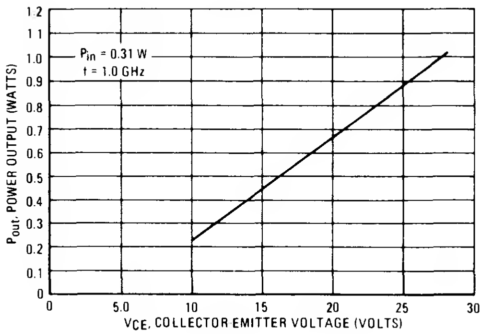

FIGURE 6 – OSCILLATOR POWER OUTPUT versus CURRENT

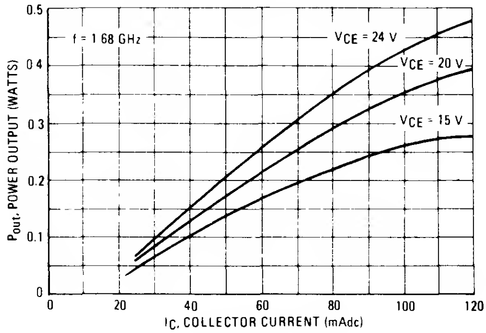

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FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

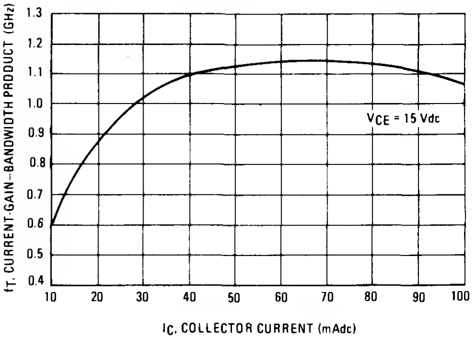
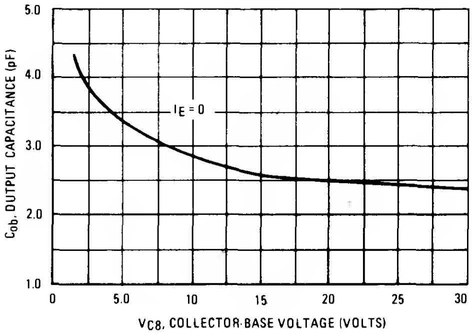


FIGURE 8 – OUTPUT CAPACITANCE versus VOLTAGE



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MRF207

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C(1) Derate above 25°C	P_D	 3.5 20	 Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

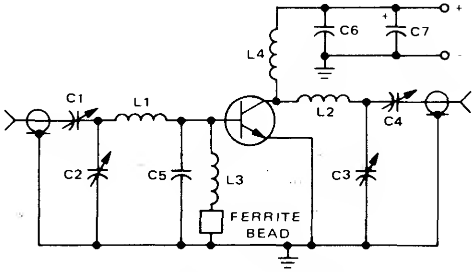
(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	—	—	—
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 1.0 W, f = 220 MHz)	G_{PE}	8.2	12.5	—	dB
Input Impedance (P_{out} = 1.0 W, f = 220 MHz)	Z_{in}	—	10−j11.5	—	Ohms
Output Impedance (P_{out} = 1.0 W, f = 220 MHz)	Z_{out}	—	32−j41	—	Ohms

220 MHz TEST CIRCUIT

FIGURE 1 – MRF207

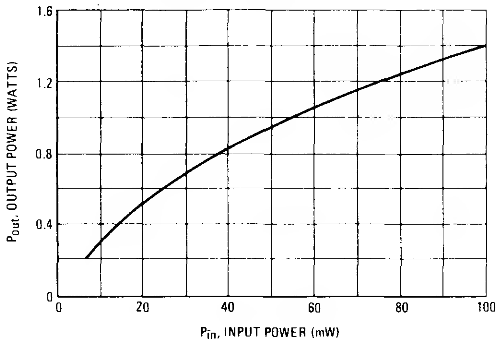


C1	2.0 - 50 pF	ARCO 461
C2, C4	5.0 - 80 pF	ARCO 462
C3	1.5 - 15 pF	ARCO 460
C5	40 pF	
C6	1000 pF	
C7	5.0 μF	TANTALUM
L1	1 Turn, #20 AWG, 1/4" ID	
L2	4 Turns, #20 AWG, 1/4 ID	
L3, L4	15 μH RFC	

OUTPUT POWER versus INPUT POWER

(V_{CC} = 12.5 Vdc, f = 220 MHz)

FIGURE 2 — MRF207



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MRF225

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

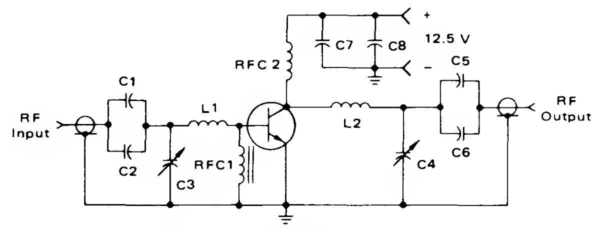
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.25	Adc
Total Device Dissipation @ T_C = 25°C(1) Derate above 25°C	P_D	3.5 0.02	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF amplifiers.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	15	150	—
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain (P_{out} = 1.5 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	G_{PE}	9.0	—	dB
Collector Efficiency (P_{out} = 1.5 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	η	50	—	%

FIGURE 1 – 225 MHz TEST CIRCUIT SCHEMATIC



C1,2,5	50 pF Dipped Mica
C3	1.5-20 pF ARCO 402
C4	4.0-40 pF ARCO 403
C6	100 pF Dipped Mica
C7	1000 pF UNELCO
C8	1.0 μF 35 V Tantalum
L1	0.6 Inch #18 AWG
L2	2 Turns x 0.25 inch ID #18 AWG
RFC 1	Ferroxcube VK200
RFC 2	2.2 μH Molded Choke

FIGURE 2 – OUTPUT POWER versus INPUT POWER

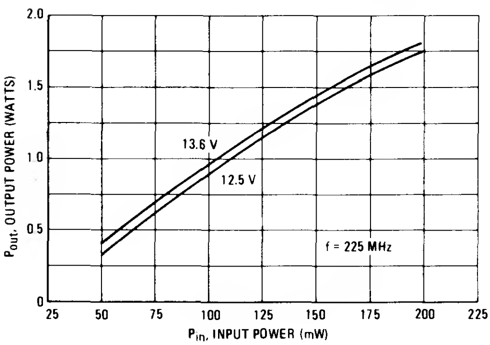
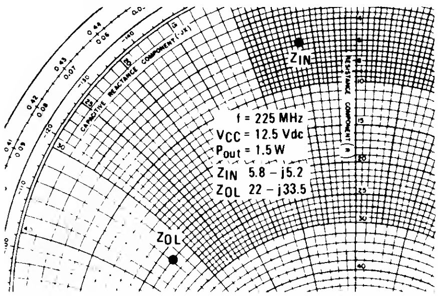


FIGURE 3 – SERIES EQUIVALENT IMPEDANCE



MRF227

CASE 79-03, STYLE 5

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	400	mdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.5	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	1.0	mAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	15	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 3.0 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	G_{PE}	13.5	15	—	dB
Collector Efficiency (P_{out} = 3.0 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	η	60	—	—	%

FIGURE 1 – 225 MHz TEST CIRCUIT

C1,C2,C3,C4	ARCO 420
C5	1000 pF, UNELCO
C6	0.047 pF, ERIE
C7	1.0 pF, TANTALUM
L1	#18 AWG, 1" Wire Length
L2	VK200-4 Ferroxcube
L3	1 Turn, #18 AWG, 1/4" ID x 2" Wire Length
L4	0.15 μH DELEVAN Molded Choke

Board – Glass Teflon, ϵ_R = 2.56, t = 0.062"
Input/Output Connectors – Type N

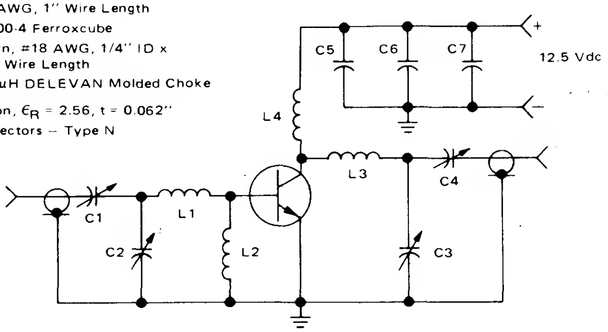


FIGURE 2 – INPUT POWER versus OUTPUT POWER – 12.5 V

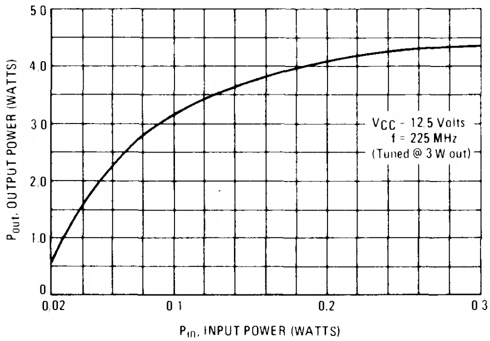


FIGURE 3 – INPUT POWER versus OUTPUT POWER – 13.6 V

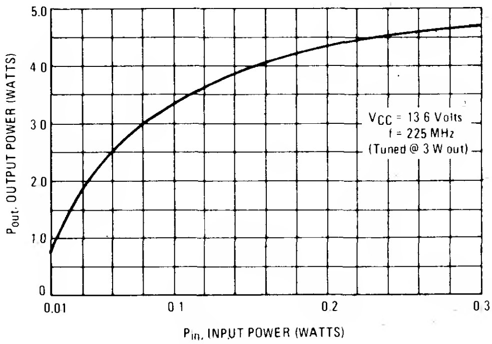


FIGURE 4 – INPUT POWER versus OUTPUT POWER – 7.5 V

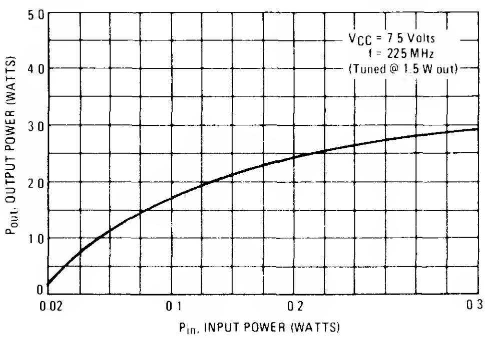


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE

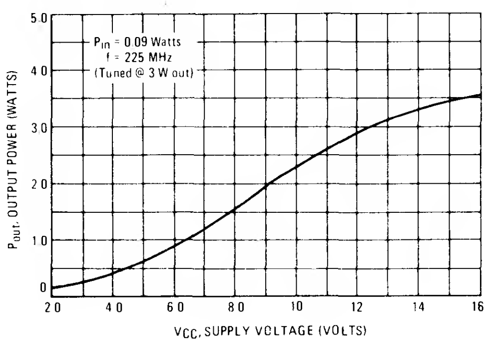
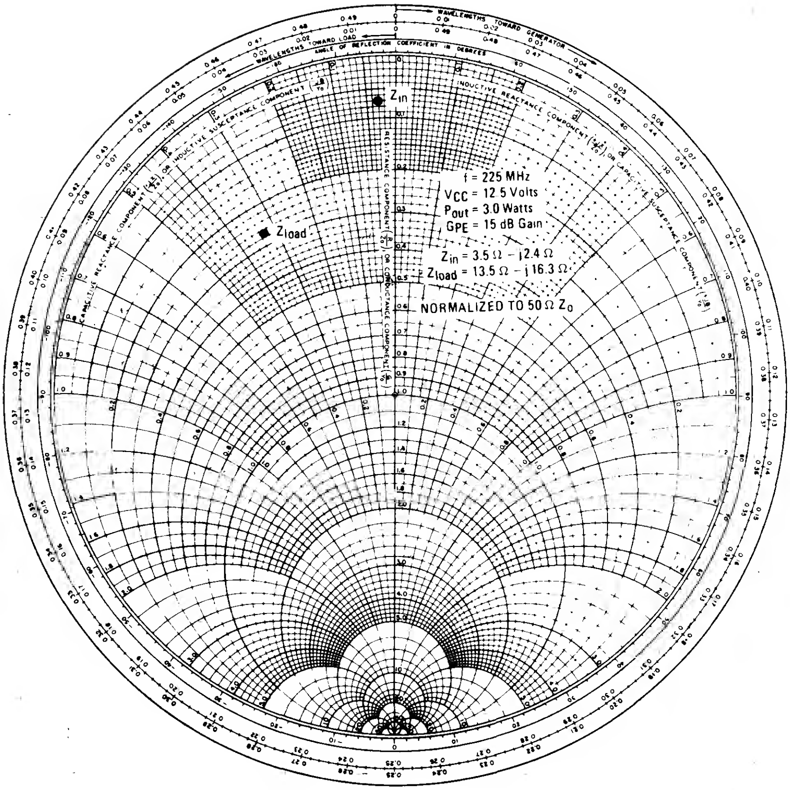


FIGURE 6 – SERIES EQUIVALENT IMPEDANCE



MRF229
MRF230

MRF229
CASE 79-03, STYLE 5

MRF230
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_C = 25°C(1) Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

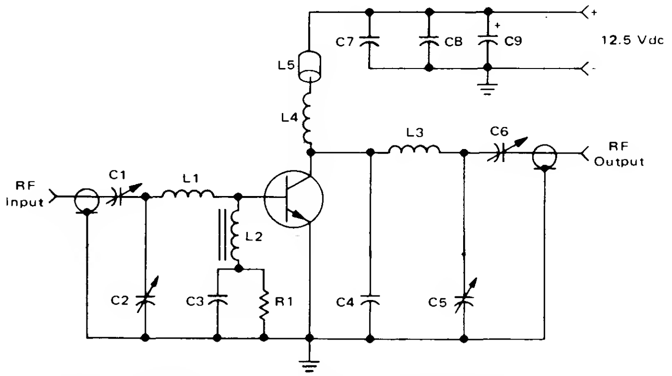
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF Amplifiers.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.25 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	0.5	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	—	—
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	25	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 90 MHz)	G_{PE}	10	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 90 MHz)	η	55	—	%
Load Mismatch (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 90 MHz, $T_C \leq$ 25°C)	—	VSWR > 30:1 Through All Phase Angles in 3 Second Interval After Which Devices Will Meet G_{PE} Test Limits		

FIGURE 1 – 90 MHz TEST CIRCUIT SCHEMATIC



C1	5.0-80 pF, ARCO 462	C9	20 μF, 15 Vdc TANTALUM
C2,C6	25-280 pF, ARCO 464	L1	2 Turns, #18 AWG, 3/8" I.D. 3/8" Long
C3	250 pF UNELCO	L2	2.5 Turns, #20 AWG, on Ferrite Bead. FERROXCUBE 56-590 65-3B
C4	10 pF UNELCO	L3	3 Turns, #18 AWG, 3/8" I.D., 1/2" Long
C5	9.0-180 pF, ARCO 463	L4	0.68 μH, 9230-16 MILLER Molded Choke
C7	1000 pF UNELCO	L5	Ferrite Bead, FERROXCUBE 56-590-65-3B
C8	0.47 μF ERIE Disc Ceramic	R1	4.7 OHM, 1/2 W, 10% Carbon

Input/Output Connectors – Type BNC

FIGURE 2 – OUTPUT POWER versus INPUT POWER

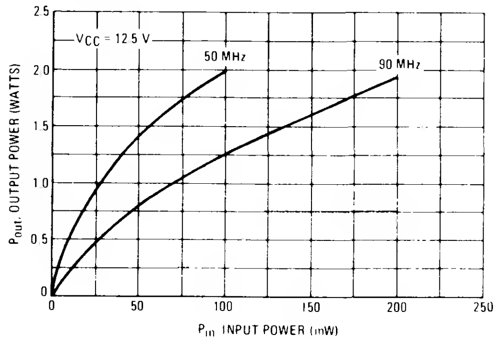


FIGURE 3 – OUTPUT POWER versus FREQUENCY

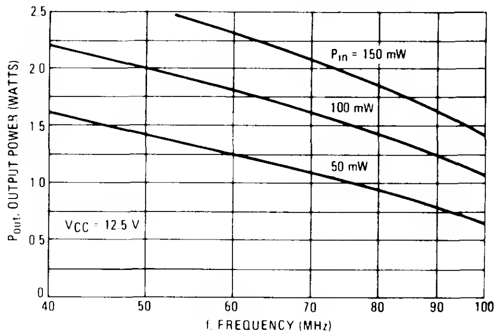


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

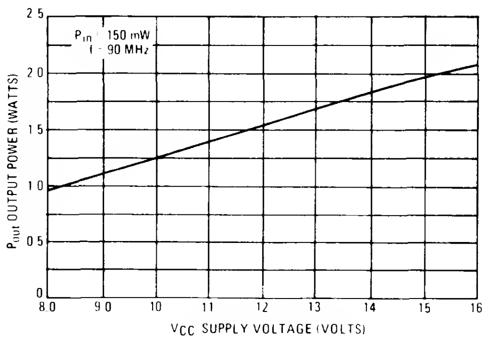
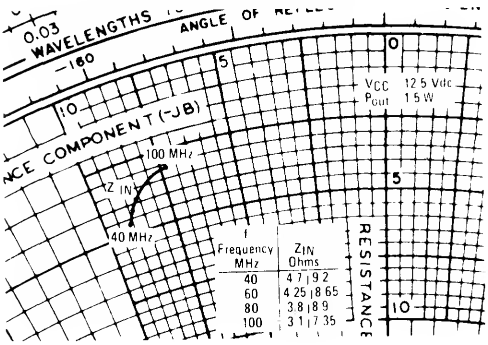


FIGURE 5

SERIES EQUIVALENT INPUT IMPEDANCE



SERIES EQUIVALENT OUTPUT IMPEDANCE

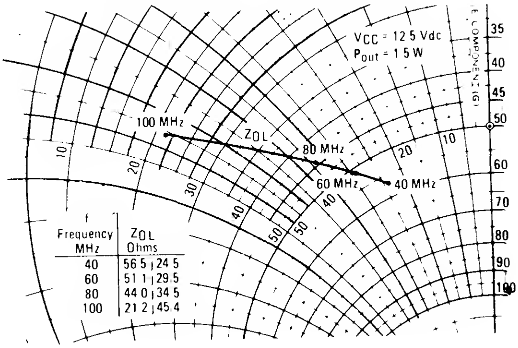


FIGURE 6 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

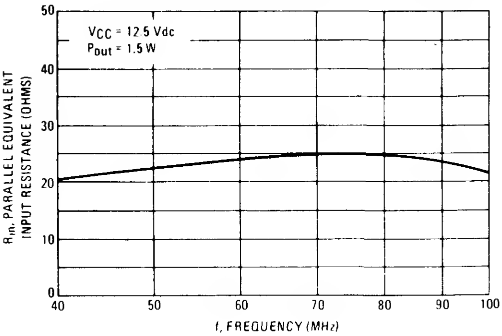


FIGURE 7 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

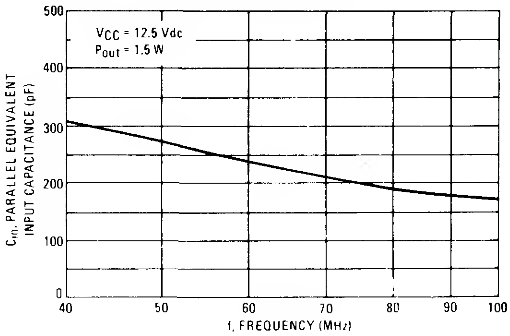


FIGURE 8 – PARALLEL EQUIVALENT OUTPUT RESISTANCE versus FREQUENCY

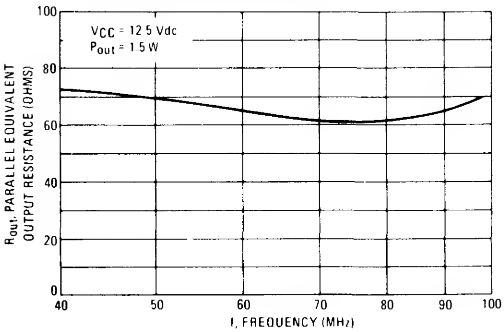
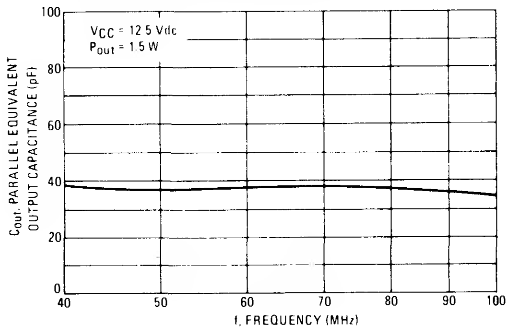


FIGURE 9 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



MRF237

CASE 79-03, STYLE 5

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	640	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.0 45.7	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

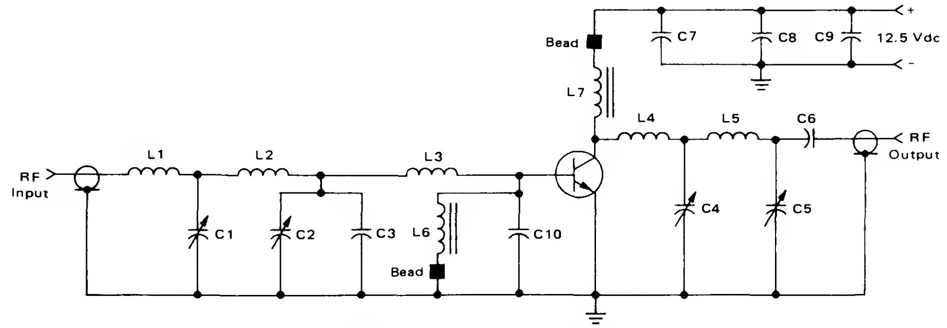
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.25	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 MHz)	C_{obo}	—	15	20	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, $I_C(max)$ = 640 mAdc, f = 175 MHz)	G_{PE}	12	14	—	dB
Collector Efficiency (P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, $I_C(max)$ = 640 mAdc, f = 175 MHz)	η	50	62	—	%

7

FIGURE 1 — 175 MHz TEST CIRCUIT SCHEMATIC



C1,C4,C5	3.0 - 180 pF, ARCO 463	L1	1/2 Turn, #16 AWG, 0.5" I.D.
C2	1.75 - 30 pF, ARCO 461	L2	1", #16 AWG
C3	40 pF, UNELCO	L3	0.75" #16 AWG
C6	0.01 μF, ERIE	L4,L5	1 Turn, #16 AWG, 0.5" I.D.
C7	0.1 μF, ERIE REDCAP	L6	0.15 μH Molded Choke
C8	1.0 μF, TANTALUM	L7	1.2 μH Molded Choke
C9	1000 pF, UNELCO	Beads	FERRITE Beads, FERROXCUBE #56-570-65/3B
C10	100 pF UNELCO		

FIGURE 2 — OUTPUT POWER versus INPUT POWER

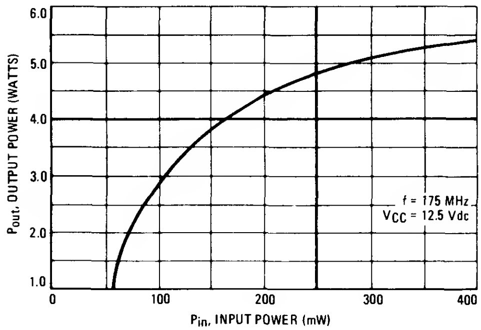


FIGURE 3 — OUTPUT POWER versus FREQUENCY

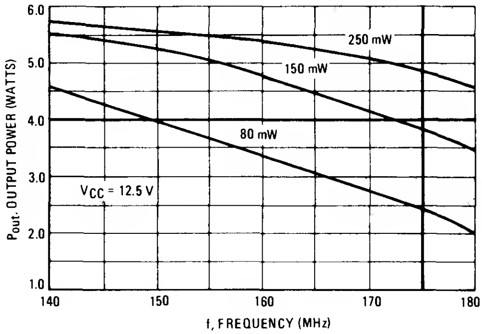


FIGURE 4 — OUTPUT POWER versus SUPPLY VOLTAGE

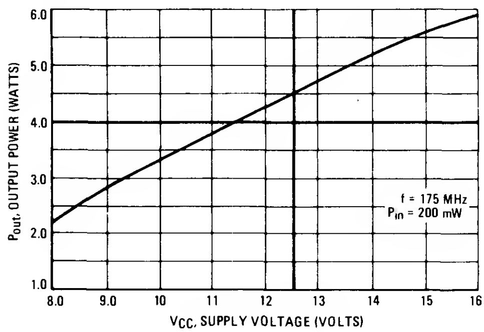
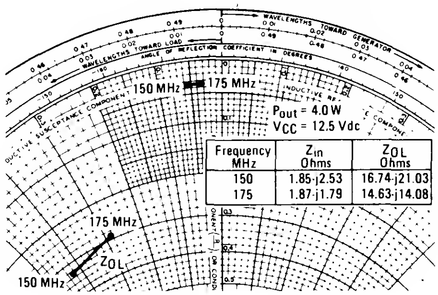


FIGURE 5 — SERIES EQUIVALENT IMPEDANCE



Frequency MHz	Z_{in} Ohms	Z_{OL} Ohms
150	1.85-j2.53	16.74-j21.03
175	1.87-j1.79	14.63-j14.08

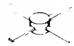
MRF313
MRF313A

MRF313
CASE 305A-01, STYLE 1

MRF313A
CASE 305-1, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 35	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

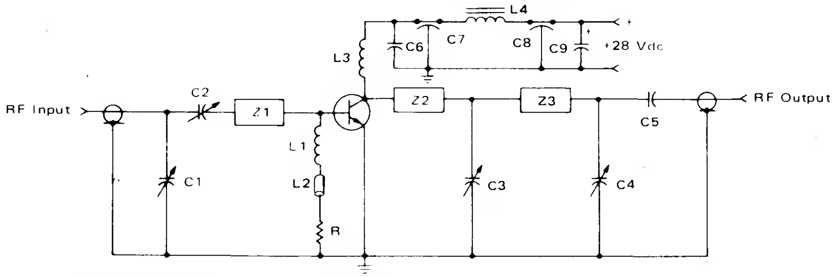
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	28.5	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	35	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	60	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	—	2.5	—	GHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	5.0	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain(1) (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	G_{pe}	15	16	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	η	—	45	—	%
Series Equivalent Input Impedance (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	Z_{in}	—	6.4−j4.8	—	Ohms
Series Equivalent Output Impedance (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	Z_{out}	—	75−j45	—	Ohms

(1) Class C

FIGURE 1 – 400 MHz POWER GAIN TEST CIRCUIT



C1,C2,C4	1.0-20 pF JOHANSON 9063	L1,L3	5 Turns, AWG #20, ¼" I.D.		
C3	1.0-10 pF JOHANSON	L2	Ferrite Bead, FERROXCUBE No. 56 590-65/4B	R	4.7 Ohms, ¼ W
C5	150 pF Chip			Z1	2.0" x 0.1" MICROSTRIP LINE
C6	0.1 μF	L4	FERROXCUBE VK200-20/4B	Z2,Z3	2.6" x 0.1" MICROSTRIP LINE
C7,C8	680 pF Feedthru		Input/Output Connectors — Type N		
C9	1.0 μF TANTALUM		Board – Glass Teflon, ε = 2.56, t = 0.062"		

7

MRF402

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

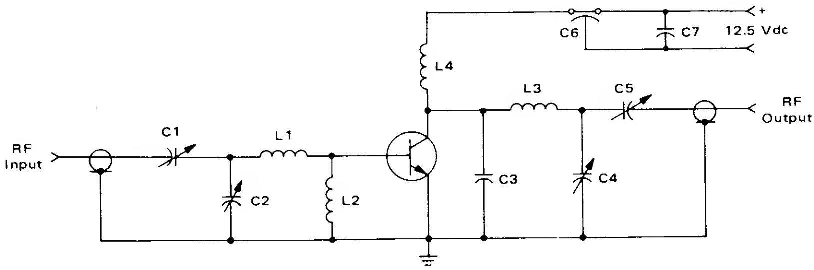
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.62	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.25 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	0.5	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	—	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	25	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 1.0 W, I_C(max) = 160 mAdc, f = 50 MHz)	G_{PE}	10	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 1.0 W, I_C(max) = 160 mAdc, f = 50 MHz)	η	50	—	%

7

FIGURE 1 — 50 MHz TEST CIRCUIT SCHEMATIC



C1,C2,C5 — 25-280 pF, ARCO 464 or equiv.
C3 — 40 pF, 500 Vdc UNELCO
C4 — 9.0-180 pF ARCO 463 or equiv.
C6 — 1000 pF feedthru
C7 — 0.1 μF, 75 Vdc

L1 — 2 Turns No. 18 AWG, 3/8" I.D.
L2 — 2 1/2 Turns, Small Ferrite Bead
L3 — 5 Turns No. 18 AWG, 3/8" I.D.
L4 — 1.0 μH RF Choke

7

MRF501
MRF502

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

Refer to 2N5179 for curves

7

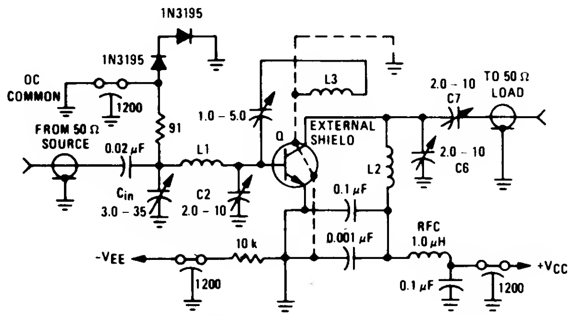
MAXIMUM RATINGS

Rating	Symbol	MRF501	MRF502	Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	25	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5		Vdc
Collector Current	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14		mW mW/°C
Storage Temperature	T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 3.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	MRF501 MRF502	$V_{(BR)CBO}$	25 35	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 1.0$ Vdc, $I_E = 0$)	MRF501 MRF502	I_{CBO}	— —	— —	50 20	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc)	MRF501 MRF502	h_{FE}	30 40	— —	250 170	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 100 MHz)	MRF501 MRF502	f_T	600 800	1000 2000	— —	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 0.1 to 1.0 MHz)		C_{cb}	—	0.6	—	pF
Collector Base Time Constant ($I_E = 2.0$ mAdc, $V_{CB} = 6.0$ Vdc, f = 31.8 MHz)		$r_b'C_c$	—	8.0	—	ps
Noise Figure (Figure 1) ($I_C = 1.5$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 50$ ohms, f = 200 MHz)	MRF501 MRF502	NF	— —	4.5 4.0	— —	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) ($V_{CC} = 6.0$ Vdc, $I_C = 5.0$ mAdc, f = 200 MHz)	MRF501 MRF502	G_{pe}	— —	15 17	— —	dB

FIGURE 1 — 200 MHz AMPLIFIER POWER GAIN
AND NOISE FIGURE CIRCUIT



L1 1 3/4 Turns, #18 AWG, 0.5" Long, 0.5" Diameter
L2 2 Turns, #16 AWG, 0.5" Long, 0.5" Diameter
L3 2 Turns, #18 AWG, 0.25" Long, 0.5" Diameter, Position Approximately 0.25" from L2

7

MRF511

CASE 244A-01, STYLE 1
TO-117

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

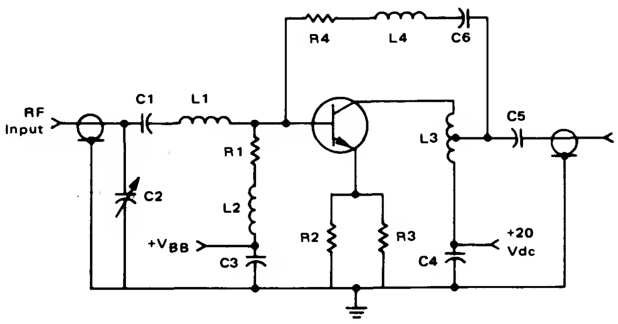
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	250	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C
Stud Torque(1)	—	6.5	In. Lb.

(1) For Repeated Assembly use 5 In. Lb.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 80 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	50	200	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.2	0.5	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 80 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	1.5	2.1	—	GHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.2	4.5	pF
Noise Figure (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	NF	—	7.3	10	dB
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CE} = 20 Vdc, I_C = 80 mAdc, f = 250 MHz)	G_{pe}	10	11	—	dB
2nd Order Intermodulation Distortion (V_{CE} = 20 Vdc, I_C = 80 mAdc, V_{out} = +50 dBmV, Chn 2 + Chn 13 = 266.5 MHz)	IMD	—	−55	−50	dB
Cross-Modulation Distortion (V_{CE} = 20 Vdc, V_{out} = +50 dBmV, I_C = 80 mAdc) Chn 13 Chn R	12 Chn XMD 30 Chn XMD	— —	−59 −46	−57 —	dB
Triple Beat (V_{CE} = 20 Vdc, I_C = 80 mAdc, V_{out} = +50 dBmV, Chn 2 + Chn 3 + Chn E = 261.75 MHz)	TB	—	−68	−65	dB

FIGURE 1 – 40 to 330 MHz BROADBAND TEST CIRCUIT SCHEMATIC



CIRCUIT PERFORMANCE	Min	Typ
Input/Output Return Loss	–	18 dB
Flatness	–	+0.3 dB
Gain	10 dB	
Bandwidth	–	40-300 MHz

C1,C3,C4,C5,C6	0.002 μF Ceramic Disc
C2	0.35-3.5 pF JOHANSON 4702
L1	2 Turns, #20 AWG, 1/8" I.D., 0.2 " Long
L2	5 μH, Ferrite Choke, MILLER
L3	18 Turns, #24 AWG Enamelled, on Ferrite Torrid Core FERROXCUBE 1041TO60-4C7
L4	5 Turns, #20 AWG, 3/16" I.D., 0.35" Long

R1	4.7 kΩ, 1/4W, 10%
R2	27 Ω, 1W, 10%
R3	27 Ω, 1W,10%
R4	300 Ω, 1/4W, 10%.

Input/Output Connectors – Type F

Z_o – 75 Ohms

FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

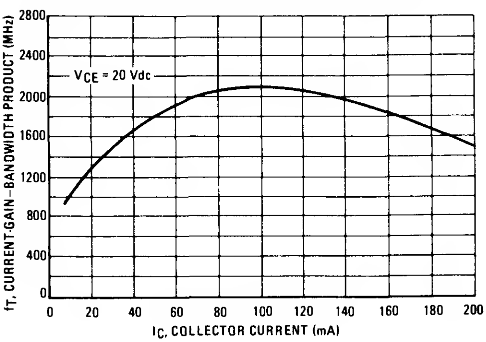


FIGURE 3 – OUTPUT CAPACITANCE

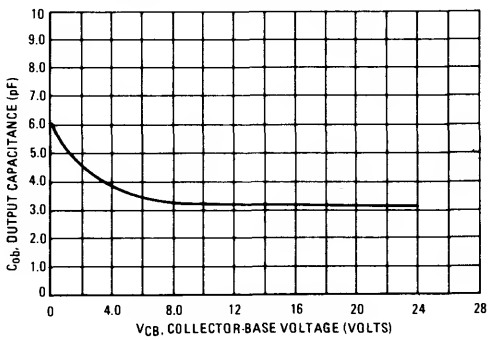


FIGURE 4 – INPUT CAPACITANCE

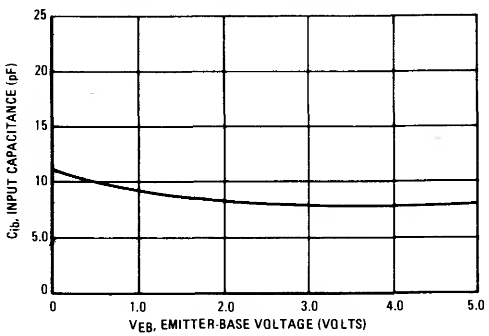


FIGURE 5 – BROADBAND NOISE FIGURE

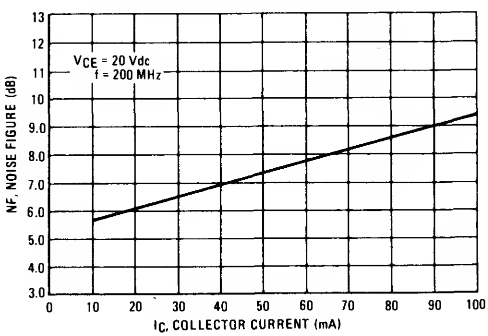


FIGURE 6 – 12 CHANNEL CROSS-MODULATION versus COLLECTOR-EMITTER VOLTAGE

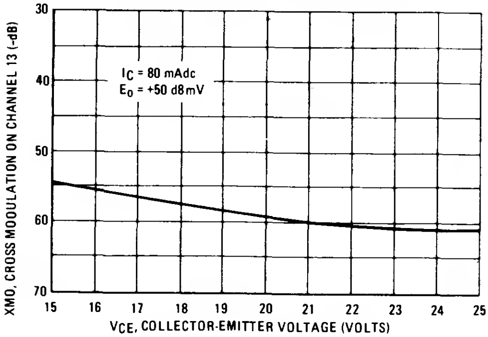


FIGURE 7 – 12 CHANNEL CROSS-MODULATION versus COLLECTOR CURRENT

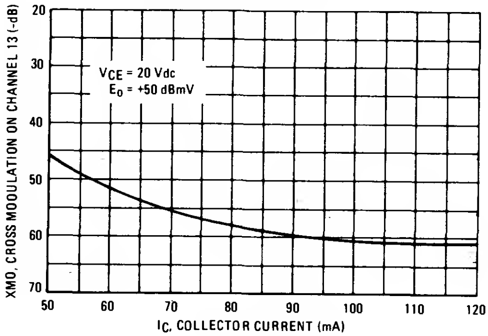


FIGURE 8 – 30 CHANNEL CROSS-MODULATION ON CHANNEL R

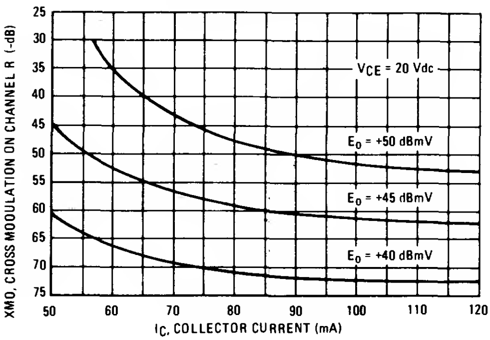


FIGURE 9 – 30 CHANNEL CROSS-MODULATION ON CHANNEL 2,13,R

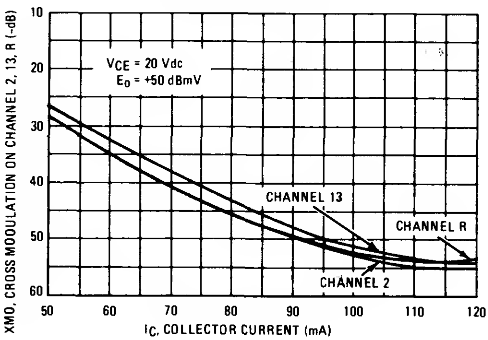


FIGURE 10 – 30-CHANNEL CROSS-MODULATION versus COLLECTOR-EMITTER VOLTAGE

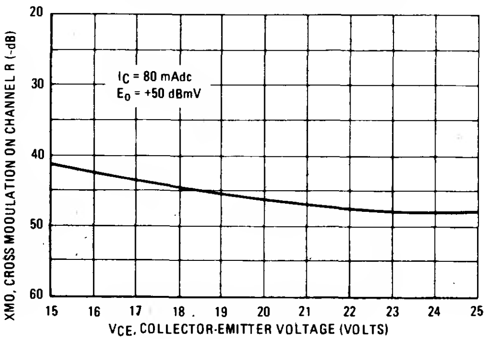


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FIGURE 11 – TRIPLE BEAT versus COLLECTOR CURRENT

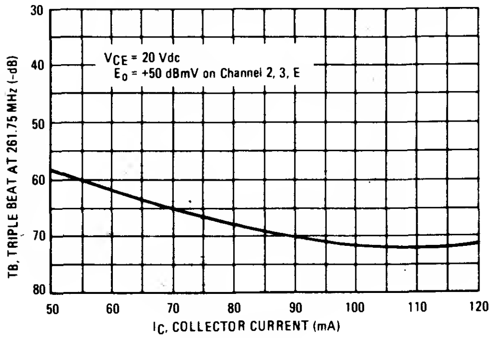

FIGURE 12 – TRIPLE BEAT versus COLLECTOR-EMITTER VOLTAGE

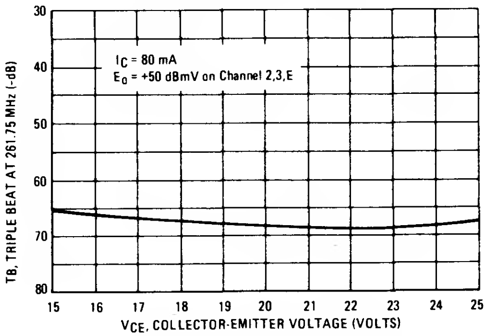

FIGURE 13 – SECOND ORDER IMD versus COLLECTOR CURRENT

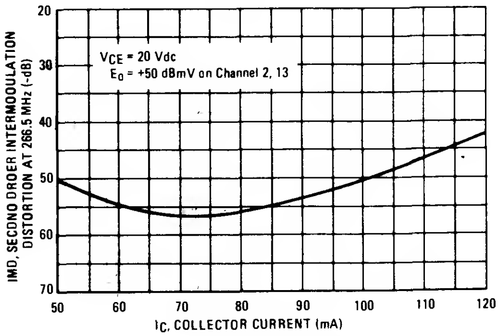

FIGURE 14 – SECOND ORDER IMD versus COLLECTOR-EMITTER VOLTAGE

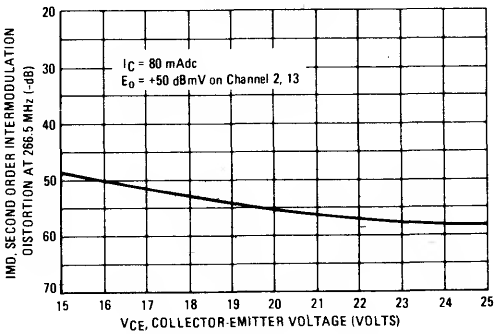

FIGURE 15 – INPUT REFLECTION COEFFICIENT (S11) AND OUTPUT REFLECTION COEFFICIENT (S22) versus FREQUENCY

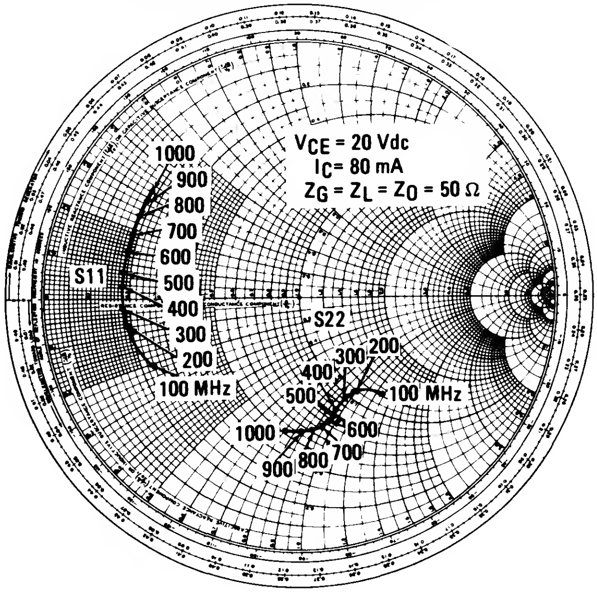

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FIGURE 16 – FORWARD TRANSMISSION COEFFICIENT (S21) versus FREQUENCY

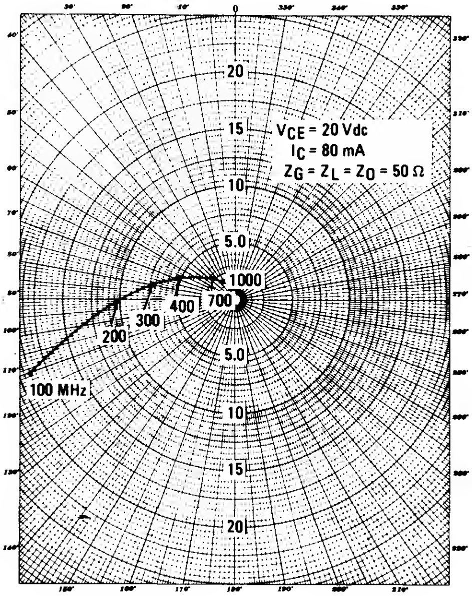
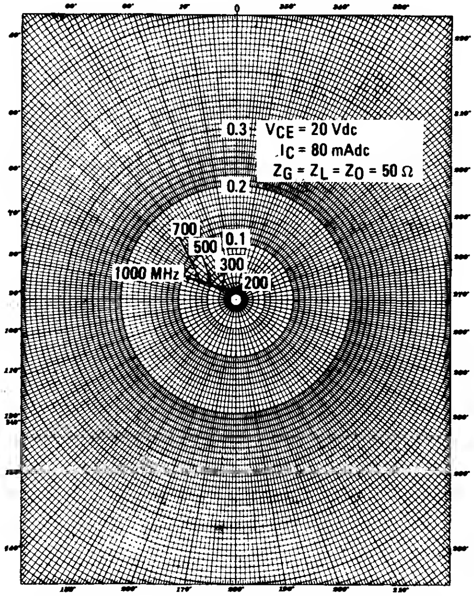


FIGURE 17 – REVERSE TRANSMISSION COEFFICIENT (S12) versus FREQUENCY



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MRF515

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

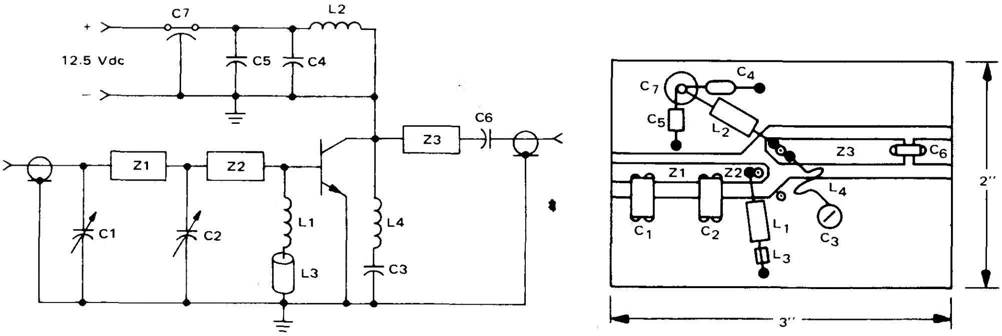
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Colector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 14.3	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	60	150	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)	f_T	1800	2000	—	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	4.0	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 470 MHz)	G_{PE}	8.0	8.5	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 470 MHz)	η	50	70	—	%
Series Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 470 MHz)	Z_{in}	—	14 + j4.0	—	Ohms
Series Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 470 MHz)	Z_{out}	—	28 − j38	—	Ohms

FIGURE 1 – 470 MHz TEST CIRCUIT



C1,C2,C3	1.0-10 pF JOHANSON
C4	0.1 μF disc
C5	1.0 μF TANTULAM
C6	0.018 μF chip
C7	1000 pF Feedthru
L1,L2	0.15 μF Choke
L3	Bead Ferrite
Z1,Z2	0.09" x 0.5" LINE, Z_o = 100 Ω
Z3	0.18" x 1.0" LINE, Z_o = 50 Ω

BOARD = 0.032" TEFLON GLASS, ϵ_R = 2.5

FIGURE 2 – OUTPUT POWER versus INPUT POWER

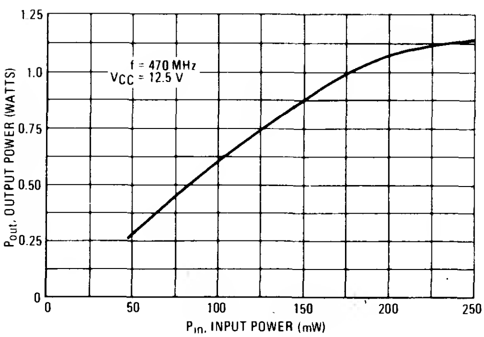


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT versus COLLECTOR CURRENT

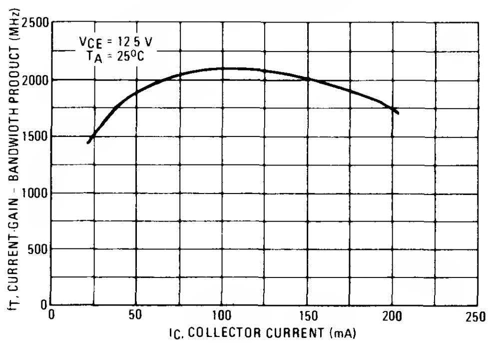


FIGURE 4 – OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE

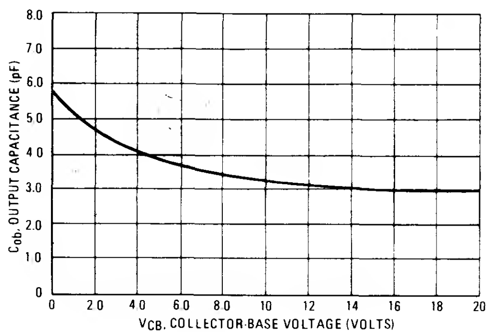


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FIGURE 5 – S_{11} and S_{22} versus FREQUENCY

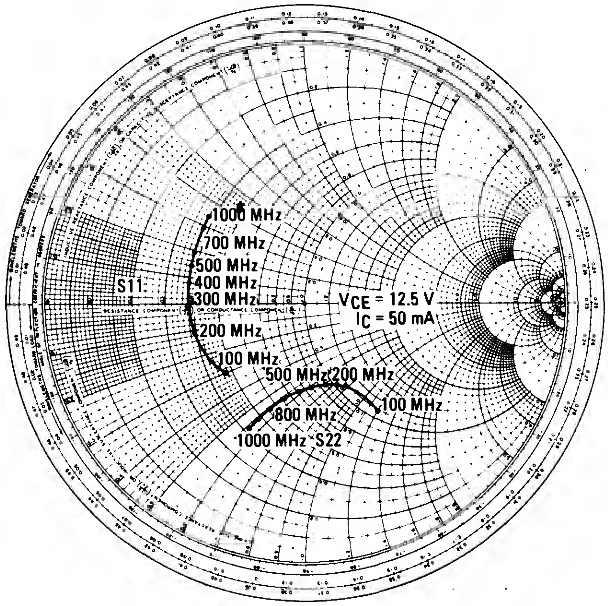

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FIGURE 6 – S_{12} versus FREQUENCY

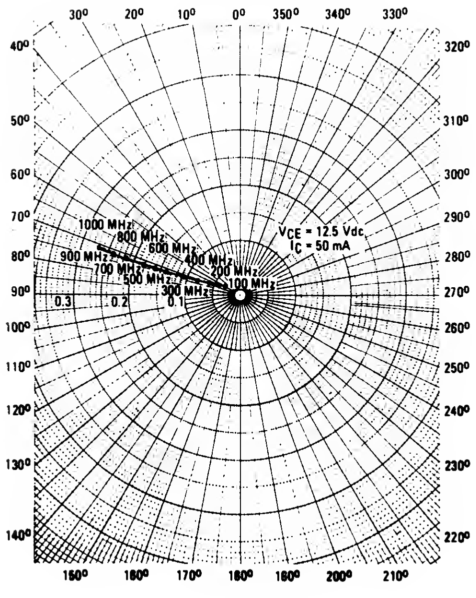
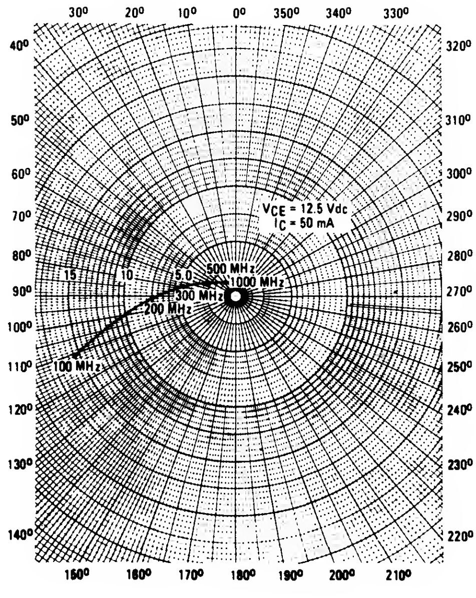


FIGURE 7 – S_{21} versus FREQUENCY



MRF517

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (R_{BE} = 330Ω)	V_{CER}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 50°C Derate above 50°C	P_D	2.5 20.0	Watts mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 330 Ohms)	$V_{(BR)CER}$	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 60 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 60 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	2200	2700	—	MHz
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	4.5	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CE} = 15 Vdc, I_C = 60 mAdc, f = 300 MHz)	G_{pe}	—	10	—	dB
Broadband Noise Figure (V_{CE} = 15 Vdc, I_C = 50 mAdc, f = 300 MHz)	NF	—	—	7.5	dB
2nd Order Distortion (V_{CE} = 15 Vdc, I_C = 60 mAdc, E_{out} = +45 dBmV, Ch 2 + Ch G = 212.5 MHz)	IMD_2	—	—	−57	dB
NCTA Cross Modulation Distortion, 12 Ch's (2–13) (V_{CE} = 15 Vdc, I_C = 60 mAdc, E_{out} = +45 dBmV, Measured at Ch's 2 and 13)	XMD_{12}	—	—	−57	dB
Triple Beat Distortion, 3 Ch's (V_{CE} = 15 Vdc, I_C = 60 mAdc, E_{out} = +45 dBmV, Ch's (4 + 5 + A) = 265 MHz)	TB_3	—	—	−72	dB

FIGURE 1 – POWER DISSIPATION

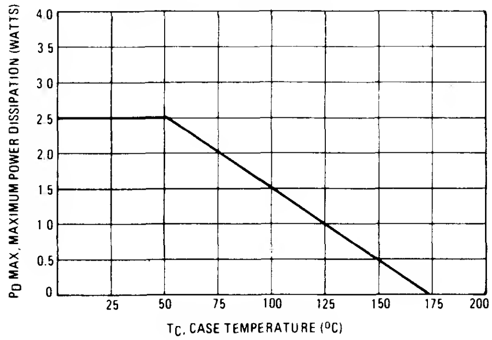
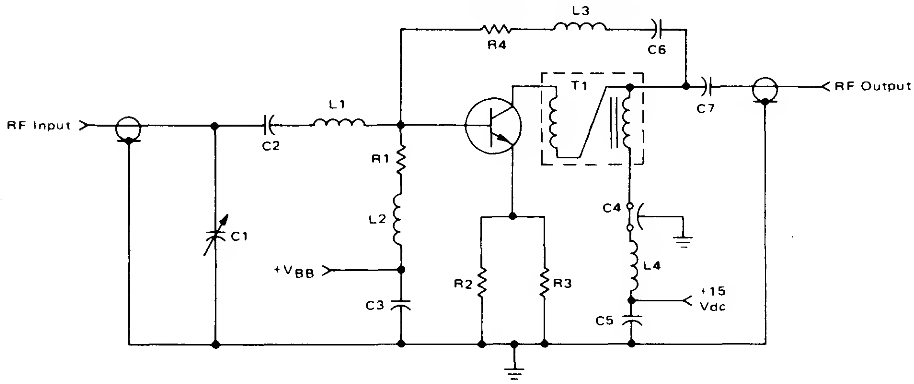


FIGURE 2 – 40 to 330 MHz BROADBAND TEST CIRCUIT SCHEMATIC



C1	1.0 – 10 pF JOHANSON
C2,C6,C7	0.002 μF Ceramic Disk
C3,C5	0.1 μF, 50 Vdc Tantalum
C4	1000 pF Button
L1	1 Turn, #20 AWG
L2	5.6 μH Molded Choke
L3	4 Turns, #20 AWG, 1/4" I.D.
L4	VK200
T1	16:1 Bifilar Wound, #20 AWG Enameled Wire, Wound on a FERROXCUBE 1041T060 4C4 Core
R1	4.7 kΩ, 1/4 Watt, 10%
R2,R3	27 Ω , 1/4 Watt, 5%
R4	270 Ω, 1/4 Watt, 5%

Input/Output Connectors – Type F
Z_o = 75 Ohms

FIGURE 3 – TYPICAL RESPONSE CURVE
(See Figure 2)

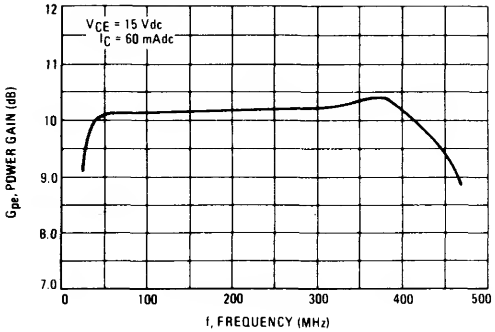


FIGURE 4 – COMMON-EMITTER POWER GAIN versus FREQUENCY

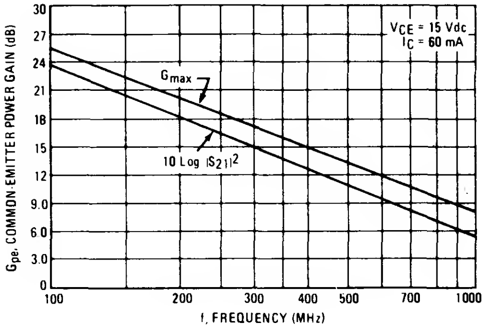


FIGURE 5 – CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT

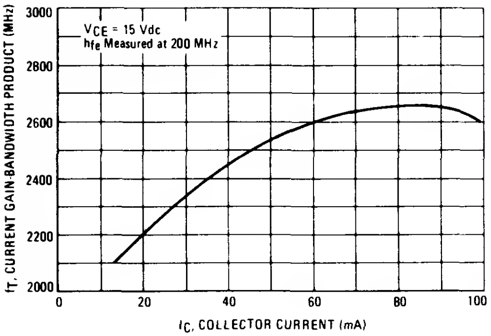


FIGURE 6 – INPUT CAPACITANCE versus EMITTER-BASE VOLTAGE

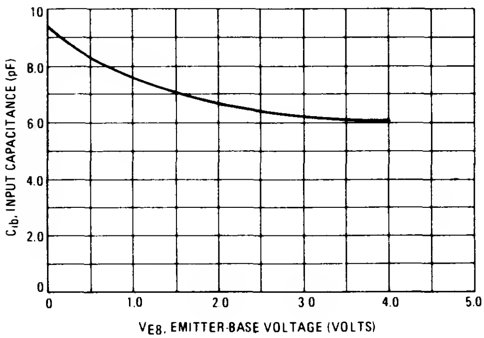


FIGURE 7 – OUTPUT CAPACITANCE versus COLLECTOR-BASE VOLTAGE

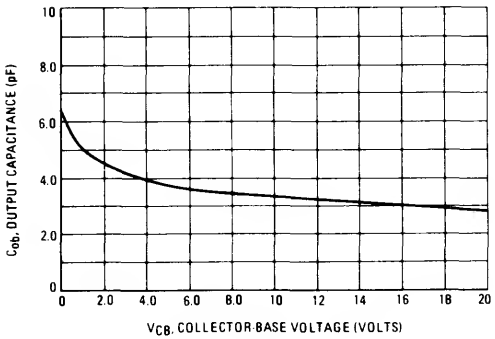


FIGURE 8 – BROADBAND NOISE FIGURE versus COLLECTOR CURRENT

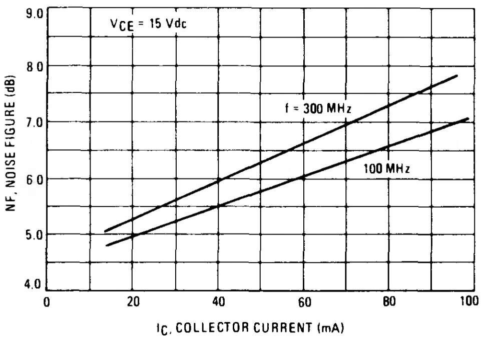


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FIGURE 9 – 2nd ORDER DISTORTION ($f_1 \pm f_2$) versus COLLECTOR CURRENT

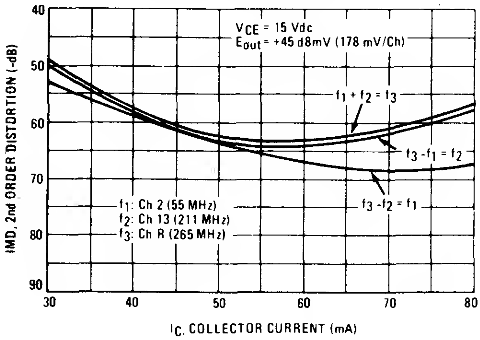


FIGURE 10 – 12-CHANNEL CROSS MODULATION DISTORTION versus COLLECTOR CURRENT

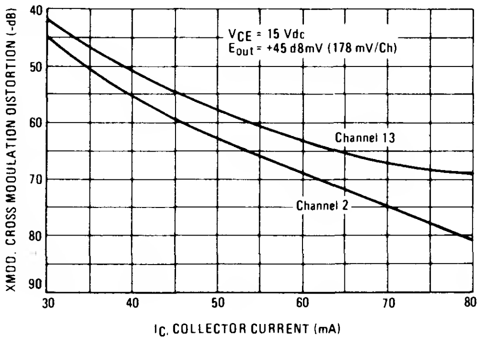


FIGURE 11 – DIN 45004 CROSS-MODULATION DISTORTION

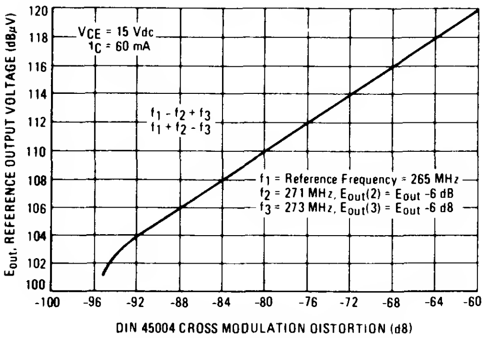


FIGURE 12 – TRIPLE BEAT DISTORTION ($f_1 + f_2 + f_3$) versus COLLECTOR CURRENT

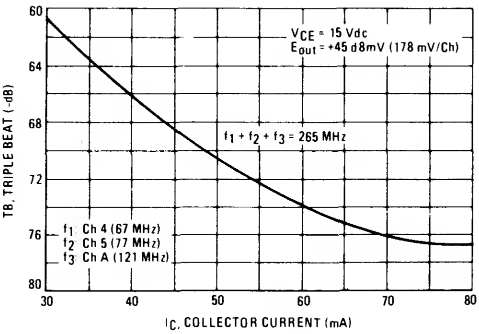
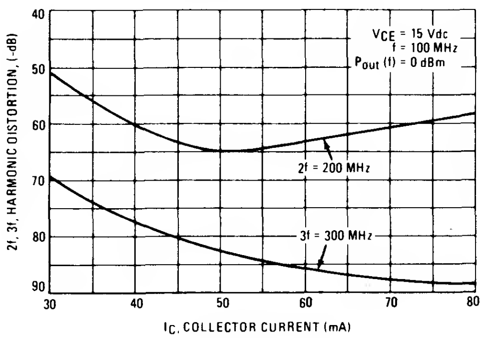


FIGURE 13 – HARMONIC DISTORTION (2f, 3f) versus COLLECTOR CURRENT



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VCE (Volts)	IC (mA)	Frequency (MHz)	S11		S21		S12		S22	
			|S11|	∠φ	|S21|	∠φ	|S12|	∠φ	|S22|	∠φ
5	30	100	0.538	-152	12.821	100	0.043	49	0.381	-102
		200	0.546	-173	6.612	86	0.064	55	0.314	-121
		400	0.557	163	3.440	71	0.105	60	0.315	-132
		600	0.602	147	2.357	59	0.144	61	0.360	-140
		800	0.625	136	1.872	46	0.181	59	0.437	-143
		1000	0.626	120	1.614	34	0.211	57	0.482	-144
	60	100	0.532	-160	13.475	98	0.040	54	0.362	-111
		200	0.542	-178	6.850	86	0.063	60	0.314	-130
		400	0.558	160	3.586	72	0.109	63	0.313	-140
		600	0.602	145	2.475	60	0.151	62	0.353	-146
		800	0.619	134	1.962	48	0.190	59	0.423	-147
		1000	0.616	118	1.706	35	0.221	57	0.464	-147
	90	100	0.532	-163	13.530	98	0.038	57	0.354	-115
		200	0.545	179	6.908	85	0.063	62	0.313	-133
		400	0.558	159	3.607	72	0.111	64	0.312	-143
		600	0.604	145	2.489	61	0.153	63	0.352	-148
		800	0.620	133	1.982	48	0.193	59	0.419	-149
		1000	0.614	117	1.721	35	0.224	57	0.455	-148
10	30	100	0.500	-145	14.176	102	0.040	50	0.386	-87
		200	0.502	-170	7.358	87	0.059	55	0.304	-105
		400	0.512	164	3.819	71	0.097	61	0.304	-118
		600	0.559	149	2.593	59	0.133	62	0.356	-128
		800	0.583	137	2.033	46	0.166	60	0.442	-134
		1000	0.584	122	1.724	34	0.194	59	0.497	-137
	60	100	0.487	-154	14.977	100	0.037	55	0.353	-96
		200	0.498	-174	7.715	86	0.059	60	0.287	-114
		400	0.506	161	4.009	72	0.101	63	0.294	-125
		600	0.553	146	2.731	60	0.139	63	0.341	-133
		800	0.572	135	2.158	47	0.174	60	0.422	-137
		1000	0.569	119	1.835	35	0.202	58	0.475	-139
	90	100	0.486	-157	15.192	99	0.036	57	0.337	-98
		200	0.493	-176	7.764	86	0.058	61	0.280	-116
		400	0.508	160	4.043	72	0.101	64	0.287	-126
		600	0.555	145	2.761	60	0.141	63	0.336	-134
		800	0.574	134	2.184	47	0.176	60	0.417	-138
		1000	0.568	118	1.861	35	0.204	58	0.469	-139
15	30	100	0.465	-153	15.774	100	0.035	56	0.337	-88
		200	0.475	-174	8.091	86	0.056	61	0.274	-105
		400	0.487	161	4 209	71	0.097	64	0.284	-116
		600	0.532	146	2.863	59	0.133	63	0.337	-126
		800	0.551	135	2 249	47	0.167	60	0.425	-132
		1000	0.547	119	1.909	34	0.193	58	0.482	-135
	60	100	0.468	-150	15.650	101	0.036	54	0.354	-87
		200	0.475	-172	8.088	87	0.057	60	0.282	-104
		400	0.486	163	4.178	72	0.096	63	0.290	-116
		600	0.530	147	2.846	60	0.133	63	0.341	-126
		800	0.549	136	2.228	47	0.166	60	0.429	-132
		1000	0.547	120	1.887	34	0.192	59	0.487	-135
	90	100	0.487	-141	14.773	103	0.039	50	0.391	-80
		200	0.486	-167	7.724	87	0.057	55	0.303	-97
		400	0.491	166	3.986	71	0.093	61	0.306	-110
		600	0.537	150	2.694	59	0.127	62	0.359	-122
		800	0.565	138	2.108	45	0.159	60	0.448	-129
		1000	0.566	123	1.779	33	0.185	60	0.507	-134

7

MRF525

CASE 79-03, STYLE 5
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage R_{BE} = 330 Ω	V_{CER}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_A = 50°C Derate above 50°C	P_D	2.5 0.017	Watts W/°C
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	−65 to +200	°C

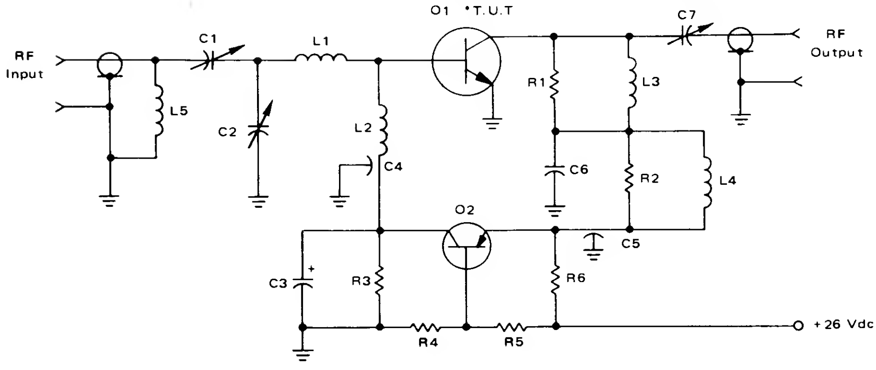
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	60	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 330 Ohms)	$V_{(BR)CER}$	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mA, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mA, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	100	μA
ON CHARACTERISTICS					
DC Current Gain (I_C = 80 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	—	175	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	2.2	2.5	—	GHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	4.0	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 26 Vdc, P_{in} = 0 dBm, f = 400 MHz)	G_{PE}	13	14	—	dB
Broadband Noise Figure (V_{CE} = 26 Vdc, f = 400 MHz)	NF	—	—	4.0	dB

FIGURE 1 — 225 to 400 MHz BROADBAND TEST CIRCUIT SCHEMATIC



C1, C2 — 2.5-11 pF Erie Ceramic Variable
C3 — 47 μF 6.0 Volt Electrolytic
C4, C5 — 1000 pF Feedthru
C6 — 470 pF Ceramic Chip
C7 — 5.5-18 pF Erie Ceramic Variable

R1 — 150 Ω 1/8 Watt Carbon
R2 — 100 Ω 1/8 Watt Carbon
R3, R4 — 10 kΩ 1/8 Watt Carbon
R5 — 3.3 kΩ 1/8 Watt Carbon

R6 — 120 Ω 1/2 Watt Carbon

L1 — 1 Turn #24, 0.125 mil ID
L2, L4 — 0.47 μH Molded Choke
L3 — 2 Turns #24, 0.125 mil ID
L5 — 4 Turns #24, 0.125 mil ID

Q2 — 2N2907A

•Transistor Under Test
I_E = 47 mAdc (Nominal)

FIGURE 2 — COMMON-EMITTER POWER GAIN (G_{max}) versus FREQUENCY

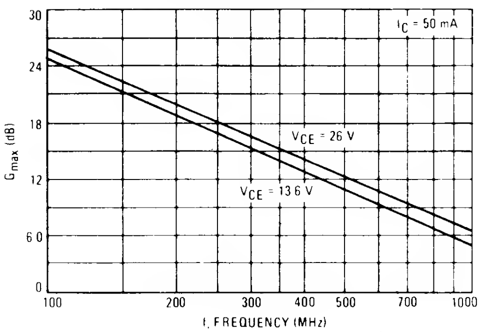


FIGURE 3 — CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT

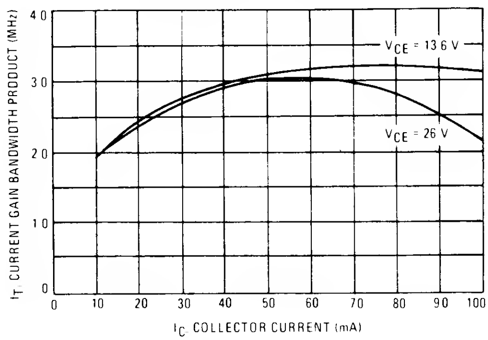


FIGURE 4 — BROADBAND AMPLIFIER RESPONSE

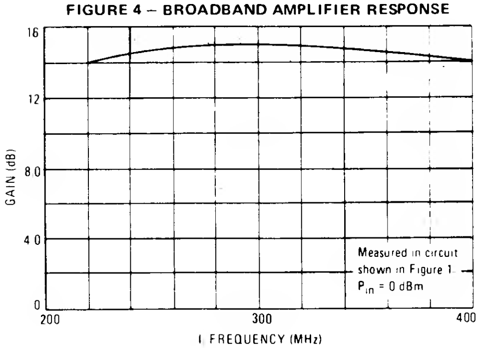


FIGURE 5 — 1.0 dB GAIN COMPRESSION OUTPUT versus FREQUENCY

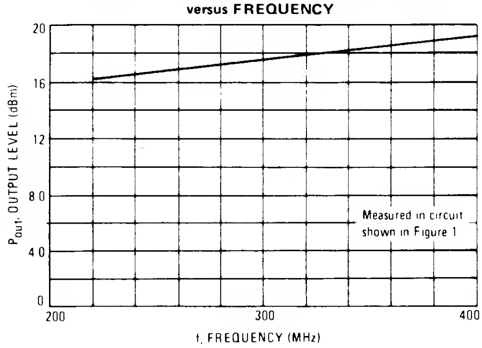
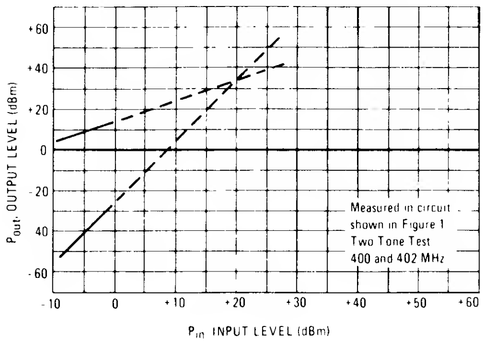


FIGURE 6 – THIRD ORDER INTERCEPT



S–PARAMETERS

V_{CE} (Volts)	I_C (mA)	Frequency (MHz)	S11 |S11|	S11 ∠φ	S21 |S21|	S21 ∠φ	S12 |S12|	S12 ∠φ	S22 |S22|	S22 ∠φ
13.6	10	100	0.388	-111	12.318	107	0.032	61	0.597	-24
		200	0.331	-151	6.768	88	0.049	68	0.480	-25
		300	0.337	-171	4.650	77	0.072	73	0.443	-31
		400	0.344	176	3.580	68	0.096	78	0.442	-40
		500	0.349	166	2.889	59	0.125	80	0.459	-47
	20	100	0.287	-125	14.160	103	0.030	67	0.516	-24
		200	0.263	-160	7.585	86	0.053	73	0.414	-23
		300	0.275	-177	5.167	76	0.078	76	0.378	-30
		400	0.288	172	3.968	68	0.104	77	0.378	-38
		500	0.293	164	3.214	60	0.135	78	0.396	-45
	50	100	0.206	-140	15.745	99	0.029	74	0.446	-24
		200	0.208	-171	8.299	84	0.056	76	0.358	-21
		300	0.226	176	5.612	75	0.084	76	0.324	-27
		400	0.235	169	4.307	68	0.113	77	0.326	-36
		500	0.243	161	3.488	60	0.114	76	0.345	-42
	100	100	0.179	-151	15.931	98	0.029	77	0.430	-22
		200	0.187	-177	8.293	85	0.058	80	0.358	-19
		300	0.203	171	5.626	77	0.087	80	0.330	-25
		400	0.212	164	4.276	70	0.115	80	0.338	-33
		500	0.213	157	3.456	63	0.147	79	0.364	-39
26	10	100	0.454	-100	13.580	105	0.027	58	0.625	-15
		200	0.313	-138	7.339	88	0.040	67	0.552	-17
		300	0.291	-161	4.989	78	0.060	76	0.532	-23
		400	0.287	-175	3.826	70	0.080	84	0.544	-30
		500	0.287	173	3.096	63	0.106	89	0.570	-36
	20	100	0.313	-105	15.191	102	0.025	62	0.566	-14
		200	0.220	-144	8.086	87	0.044	73	0.509	-15
		300	0.213	-166	5.487	77	0.067	78	0.489	-20
		400	0.215	-178	4.204	71	0.092	83	0.498	-28
		500	0.214	170	3.404	64	0.116	86	0.523	-34
	50	100	0.165	-117	16.375	102	0.026	71	0.529	-14
		200	0.139	-157	8.695	87	0.048	78	0.471	-14
		300	0.151	-176	5.882	78	0.073	80	0.449	-20
		400	0.157	173	4.494	71	0.098	82	0.458	-27
		500	0.158	164	3.659	65	0.124	84	0.485	-32
	100	100	0.215	-147	13.156	103	0.023	72	0.602	-14
		200	0.212	-176	7.220	88	0.044	82	0.536	-17
		300	0.222	171	4.951	79	0.069	84	0.507	-24
		400	0.230	164	3.851	72	0.093	87	0.513	-31
		500	0.233	156	3.123	64	0.123	89	0.534	-36

MRF531

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 14.3	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	70	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	100	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	100	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 25 Vdc, f = 100 MHz)	f_T	500	800	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Input Capacitance (V_{BE} = 3.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	9.0	—	pF

7

FIGURE 1 — CURRENT-GAIN — BANDWIDTH PRODUCT

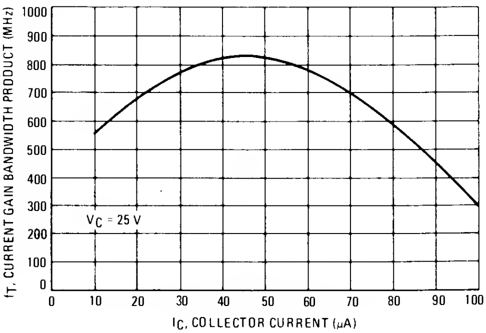


FIGURE 2 — INPUT CAPACITANCE

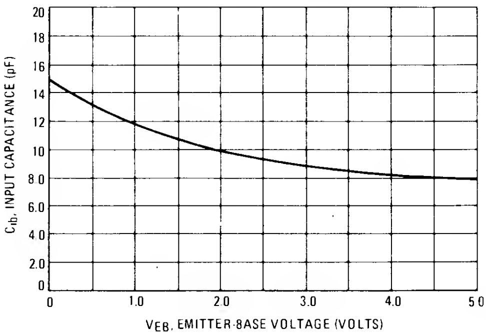


FIGURE 3 — OUTPUT CAPACITANCE

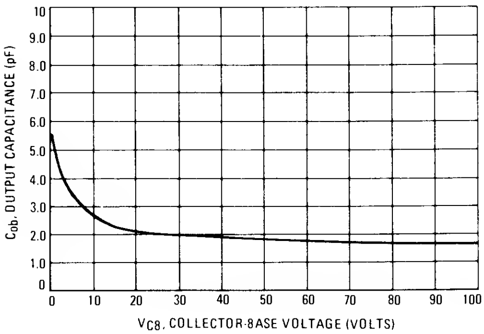
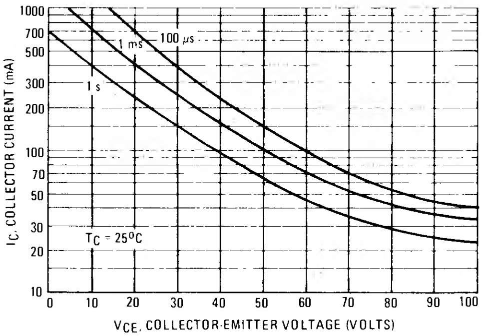


FIGURE 4 — DC SAFE OPERATING AREA



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MRF532

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Volts
Collector-Base Voltage	V_{CBO}	80	Volts
Emitter-Base Voltage	V_{EBO}	3.5	Volts
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 14.3	Watts mW/°C
Storage Temperature	T_{stg}	−60 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	70	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mA)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mA)	$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current ($V_{CE} = 75$ V)	I_{CES}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 5.0$ mA, $V_{CE} = 10$ V)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{CE(sat)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mA, $V_{CE} = 25$ V, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)	C_{obo}	—	4.0	pF

MRF534, MRF536

For Specifications, See MM4049 Data.

MRF559

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

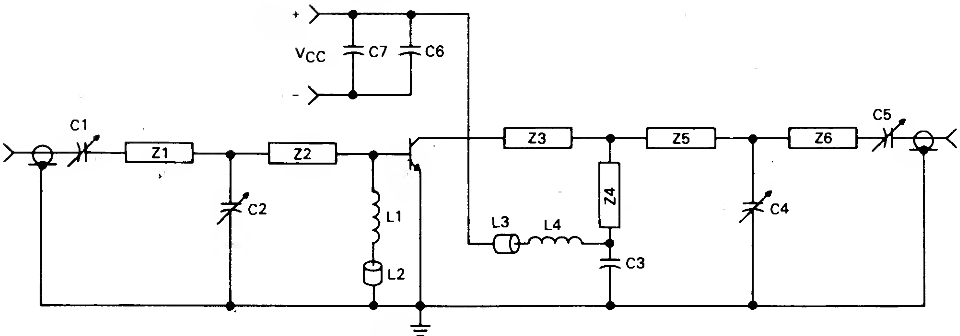
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 50°C Derate above 50°C	P_D	2.0 20	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	—	—	1.0	mAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)		h_{FE}	30	90	200	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)		f_T	—	3000	—	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	2.0	2.5	pF
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	G_{PE}	8.0 —	9.5 13	— —	dB
Collector Efficiency (Figure 1) (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	η	50 —	65 60	— —	%
TYPICAL PERFORMANCE @ V_{CC} = 7.5 V						
Common-Emitter Amplifier Power Gain (V_{CC} = 7.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	G_{PE}	— —	6.5 10	— —	dB
Collector Efficiency (V_{CC} = 7.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	η	— —	70 65	— —	%

FIGURE 1 — 870 MHz TEST FIXTURE



C1, C2, C4, C5 — 1.0-10 pF Johanson
C3, C6 — 0.001 μF Chip Capacitor
C7 — 1.0 μF Tantulam
L1, L4 — 4 Turns #26 AWG, 0.3 cm ID, 0.4 cm Long
L2, L3 — Ferrite Bead
Microstrip Elements — $\epsilon_r = 1.0$

Z1 — 50 Ω 1.5 cm
Z2 — 30 Ω 2.5 cm
Z3 — 50 Ω 2.0 cm
Z4 — 50 Ω 1.2 cm
Z5, Z6 — 50 Ω 1.25 cm

FIGURE 2 — OUTPUT POWER versus INPUT POWER
f = 512 MHz

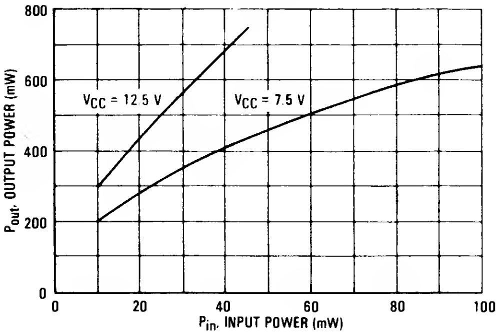


FIGURE 3 — OUTPUT POWER versus FREQUENCY
$V_{CC} = 7.5$ V

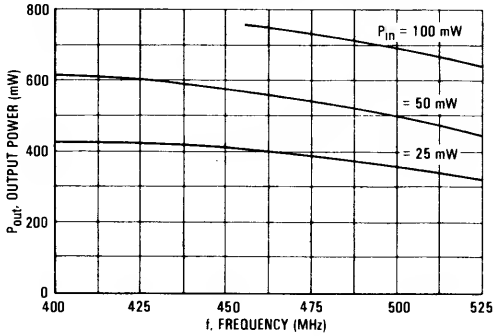


FIGURE 4 — OUTPUT POWER versus COLLECTOR VOLTAGE
f = 512 MHz

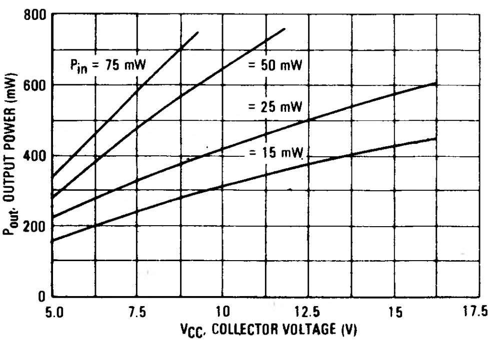


FIGURE 5 — OUTPUT POWER versus FREQUENCY
$V_{CC} = 12.5$ V

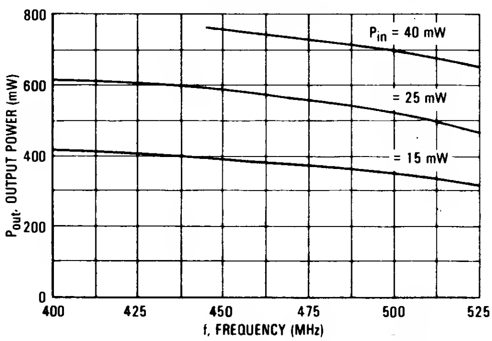


FIGURE 6 — Z_{in} AND Z_{OL} versus COLLECTOR VOLTAGE, INPUT POWER, AND OUTPUT POWER

f FREQUENCY MHz	Z_{in} OHMS			Z_{OL}* OHMS					
	V_{CC} = 7.5-12.5 V			V_{CC} = 7.5 V			V_{CC} = 12.5 V		
	15 mW	25 mW	50 mW	0.25 W	0.50 W	0.75 W	0.25 W	0.50 W	0.75 W
400	4.3 - j13.3	4.9 - j11.0	5.7 - j8.7	31 - j49	44 - j34	42 - j4.9	20 - j68	42 - j60	52 - j54
440	3.9 - j8.8	4.5 - j8.7	5.4 - j6.9	27 - j42	39 - j30	40 - j6.9	19 - j62	37 - j54	49 - j50
480	3.5 - j4.4	4.1 - j6.5	5.0 - j4.3	24 - j36	36 - j25	39 - j9.0	18 - j56	33 - j48	47 - j46
520	3.2 - j2.2	3.8 - j4.3	4.7 - j1.7	22 - j30	34 - j20	37 - j12	17 - j52	31 - j44	47 - j42

*Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

FIGURE 7 — OUTPUT POWER versus INPUT POWER
f = 870 MHz

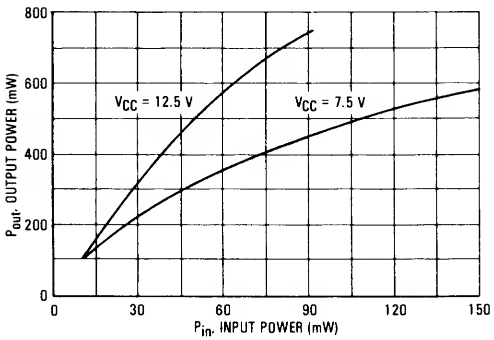


FIGURE 8 — OUTPUT POWER versus FREQUENCY
V_{CC} = 7.5 V

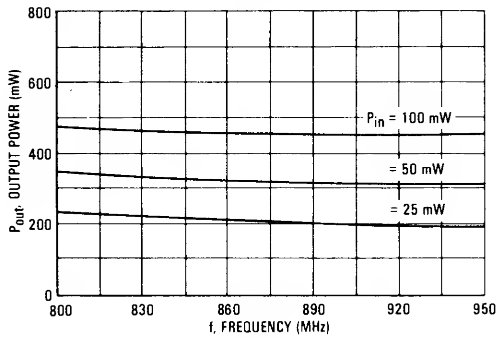


FIGURE 9 — OUTPUT POWER versus COLLECTOR VOLTAGE
f = 870 MHz

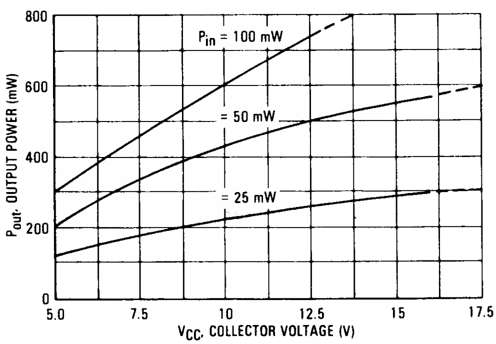


FIGURE 10 — OUTPUT POWER versus FREQUENCY
V_{CC} = 12.5 V

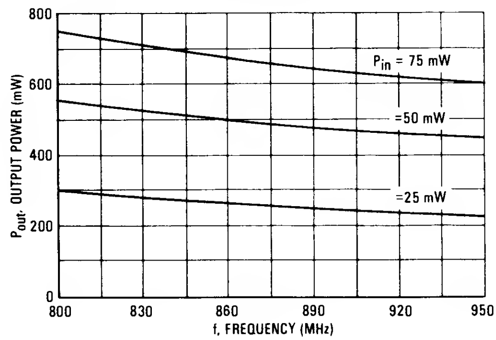
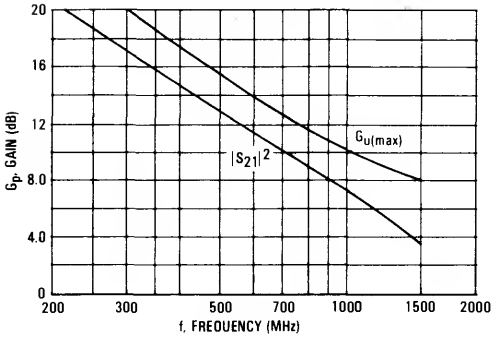


FIGURE 11 — Z_{in} AND Z_{OL} versus COLLECTOR VOLTAGE, INPUT POWER, AND OUTPUT POWER

f FREQUENCY MHz	Z_{in} OHMS			Z_{OL}* OHMS					
	V_{CC} = 7.5-12.5 V			V_{CC} = 7.5 V			V_{CC} = 12.5 V		
	25 mW	50 mW	100 mW	0.25 W	0.50 W	0.75 W	0.25 W	0.50 W	0.75 W
800	2.9 + j2.2	3.8 + j4.4	4.7 + j6.5	15.0 - j36.8	22.7 - j30.6	27.1 - j22.6	14.6 - j43.6	17.2 - j39.7	23.4 - j37.7
850	3.2 + j3.5	3.8 + j5.2	4.8 + j7.4	15.7 - j35.3	23.9 - j28.7	27.3 - j21.5	16.3 - j40.8	17.8 - j39.5	23.7 - j36.8
900	3.8 + j5.7	4.4 + j7.0	5.4 + j8.7	16.4 - j33.7	25.1 - j27.0	27.5 - j20.5	17.3 - j38.2	18.3 - j39.3	23.9 - j36.0
950	4.1 + j7.4	4.5 + j8.8	5.5 + j10.1	17.0 - j32.2	26.3 - j25.2	27.6 - j19.4	17.2 - j36.1	20.1 - j38.5	24.5 - j35.6

*Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

FIGURE 12 — GAIN versus FREQUENCY
V_{CE} = 10 V, I_C = 50-100 mA



$$G_{u(max)} = \frac{|S_{21}|^2}{(1-|S_{11}|^2)\,(1-|S_{22}|^2)}$$

FIGURE 13 — GAIN versus COLLECTOR CURRENT
V_{CE} = 10 V

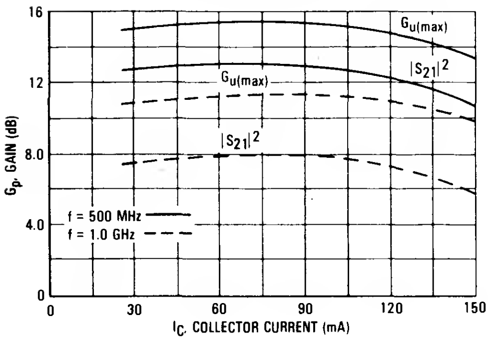


FIGURE 14 — NOISE FIGURE AND ASSOCIATED GAIN versus COLLECTOR CURRENT
V_{CE} = 10 V

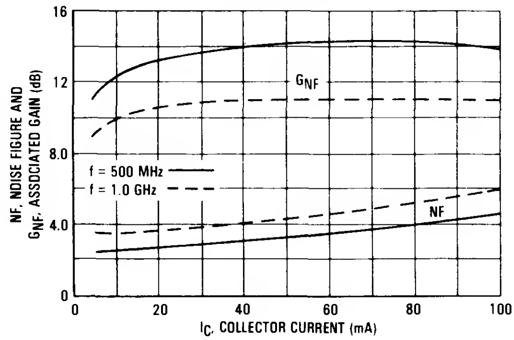


FIGURE 15 — CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT
V_{CE} = 10 V

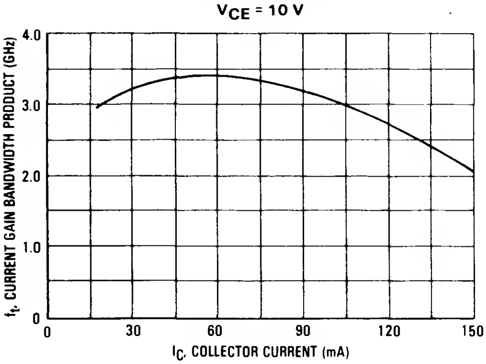


FIGURE 16 — OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE

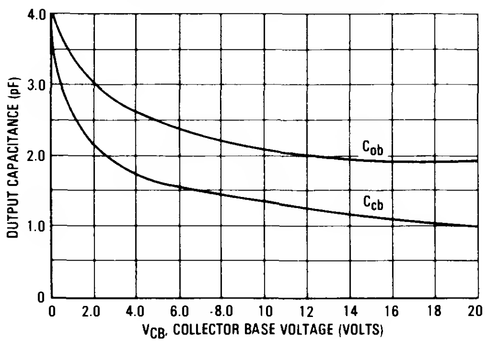


FIGURE 17 — COMMON EMITTER SCATTERING PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11} \rvert$	$\angle\phi$	$\lvert S_{21} \rvert$	$\angle\phi$	$\lvert S_{12} \rvert$	$\angle\phi$	$\lvert S_{22} \rvert$	$\angle\phi$
5.0	10	250	0.72	-161	6.20	93	0.057	30	0.30	-91
		500	0.73	179	3.16	76	0.069	43	0.27	-94
		1000	0.76	158	1.62	55	0.105	63	0.27	-119
		1500	0.82	142	1.08	41	0.155	70	0.41	-137
	25	250	0.70	-173	7 17	89	0.045	47	0.26	-123
		500	0.70	172	3 63	75	0.073	60	0.20	-128
		1000	0.74	152	1.90	54	0.134	67	0.21	-157
		1500	0.79	136	1.32	39	0.196	66	0.32	-167
	50	250	0.72	-178	7 63	89	0.038	56	0.27	-139
		500	0.72	170	3.85	77	0068	67	0.23	-141
		1000	0.75	153	2.01	59	0.129	72	0.23	-162
		1500	0.81	137	1.40	46	0.188	70	0.32	-164
	100	250	0.73	179	7.34	88	0.036	61	0.26	-143
		500	0.74	169	3.70	77	0.067	71	0 22	-144
		1000	0.76	153	1.94	59	0.130	74	0.24	-166
		1500	0.81	138	1.36	46	0.191	71	0.32	-167
	150	250	0.78	176	5.19	92	0.033	64	0.22	-131
		500	0.78	167	2.76	78	0.065	74	0.21	-131
		1000	0.80	151	1.49	58	0.129	77	0.24	-155
		1500	0.85	135	1.05	45	0.191	73	0.35	-161
10	10	250	0.69	-157	7.03	94	0.050	33	0.34	-67
		500	0.70	-178	3.59	77	0.060	46	0.32	-69
		1000	0.74	160	1.84	55	0.094	67	0.29	-94
		1500	0.81	142	1.20	41	0.148	76	0.42	-121
	25	250	0.67	-168	8.30	91	0.039	46	0.24	-93
		500	0.68	176	4.25	77	0.060	60	0.21	-89
		1000	0.72	158	2.19	57	0.109	71	0.19	-114
		1500	0.78	142	1.47	44	0.165	74	0.31	-134
	50	250	0.68	-174	8.88	90	0.035	55	0.21	-110
		500	0.68	172	4.49	77	0.060	67	0.18	-104
		1000	0.72	155	2.31	59	0.113	74	0.17	-128
		1500	0.77	139	1.58	46	0.169	74	0.28	-140
	100	250	0.68	-178	8.49	89	0.03	61	0.19	-104
		500	0.69	170	4.32	76	0.06	71	0.17	-97
		1000	0.72	153	2.25	58	0.12	76	0.17	-123
		1500	0.78	137	1.53	44	0.18	75	0.28	-137
	150	250	0.72	178	6.53	91	0.029	64	0.22	-71
		500	0.73	169	3.37	77	0.056	75	0.24	-75
		1000	0.76	152	1.79	57	0.112	80	0.22	-105
		1500	0.83	137	1.22	43	0.175	79	0.34	-129

FIGURE 18 — TUNABLE TEST FIXTURE

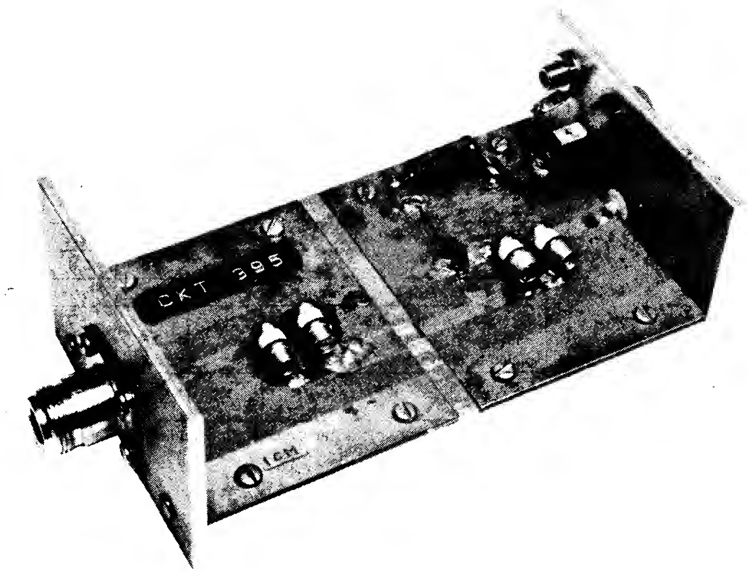
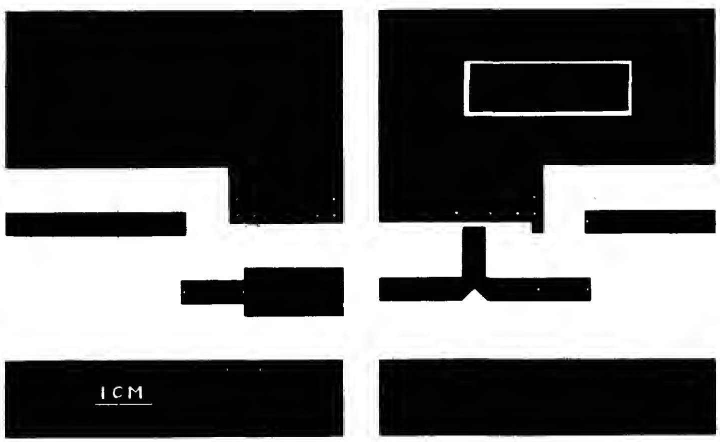


FIGURE 19 — PRINTED CIRCUIT BOARD LAYOUT

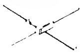


INPUT

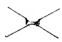
OUTPUT

MRF571
MRF572
MRF573

MRF571
CASE 317-01, STYLE 2



MRF572
CASE 303-01, STYLE 1



MRF573
CASE 358-01, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MRF571	MRF572	MRF573	Unit
Collector-Emitter Voltage	V_{CEO}	10	10	10	Vdc
Collector-Base Voltage	V_{CBO}	20	20	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	3.0	3.0	Vdc
Collector Current — Continuous	I_C	70	70	70	mAdc
Total Device Dissipation @ T_C = 100°C(1) Derate above 100°C	P_D	0.5 5.0	0.75 7.5	0.75 7.5	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +150	−65 to +200	−65 to +200	°C

(1) Case temperature measured on collector lead immediately adjacent to body of package.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.1 mAdc, I_B = 0)	$V_{(BR)CEO}$	10	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 50 μAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 8.0 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	—	300	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 8.0 V_{DC}, I_C = 50 mA, f = 1.0 GHz)	f_T	—	8.0	—	GHz
Collector-Base Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	.7	1.0	pF
FUNCTIONAL TEST					
Noise Figure (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = .50 GHz) (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 GHz) (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 2.0 GHz) MRF571 (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 2.0 GHz) MRF572,573	NF	 — — — —	 1.0 1.5 2.8 2.5	 — 2.0 — —	dB
Gain @ Noise Figure (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = .50 GHz) (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)	G_{NF}	 — 10	 16.5 12	 — —	dB

FIGURE 1 — C_{cb}, COLLECTOR-BASE CAPACITANCE versus VOLTAGE

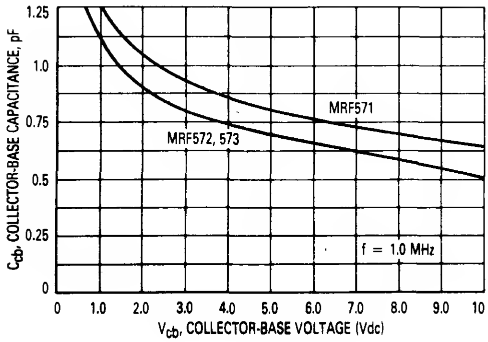


FIGURE 2 — C_{ib}, INPUT CAPACITANCE versus EMITTER BASE VOLTAGE

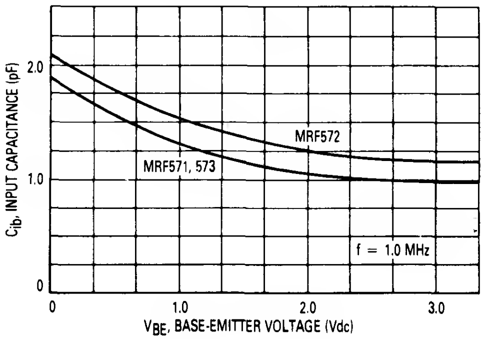


FIGURE 3 — MRF571 — GAIN AT NOISE FIGURE AND NOISE FIGURE versus FREQUENCY

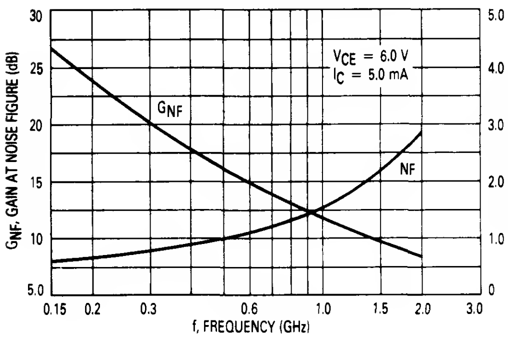


FIGURE 4 — MRF572, MRF573 — GAIN AT NOISE FIGURE AND NOISE FIGURE versus FREQUENCY

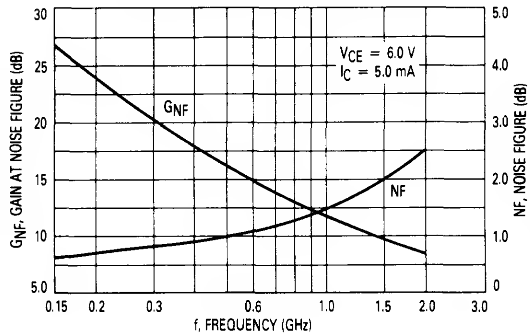


FIGURE 5 — MRF571, MRF572 and MRF573 — GAIN AT NOISE FIGURE AND NOISE FIGURE versus COLLECTOR CURRENT

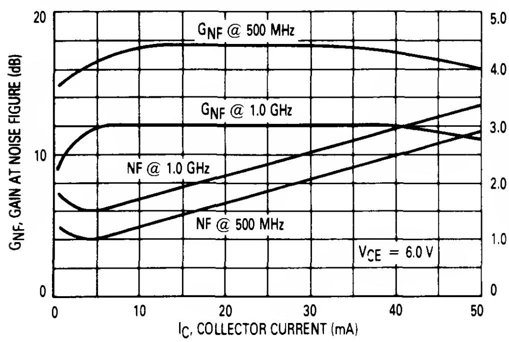


FIGURE 6 — f_T, CURRENT GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

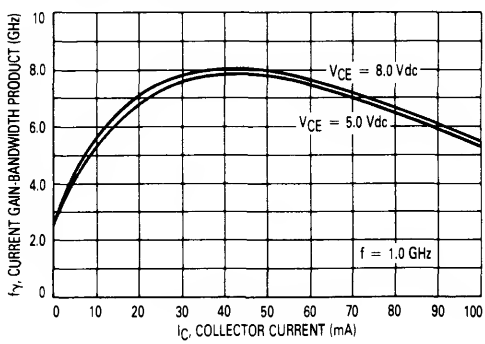


FIGURE 7 — G_A MAX, MAXIMUM AVAILABLE GAIN versus FREQUENCY

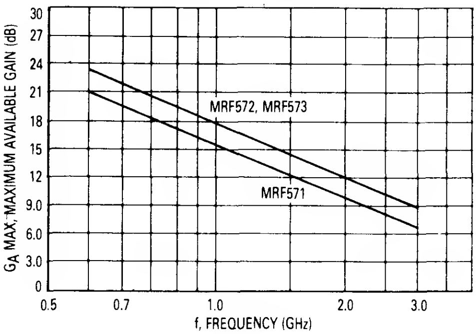


FIGURE 8 — 1.0 dB COMPRESSION PT. AND THIRD ORDER INTERCEPT

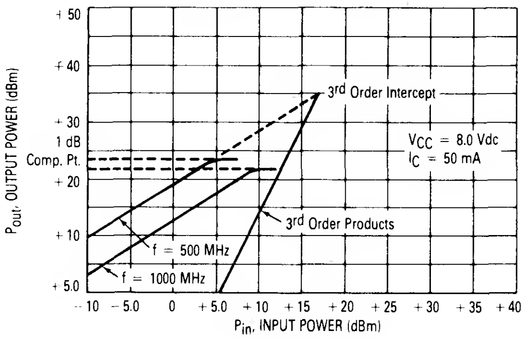


FIGURE 9 — MRF571 — $G_U$max and $|S_{21}|^2$ versus FREQUENCY

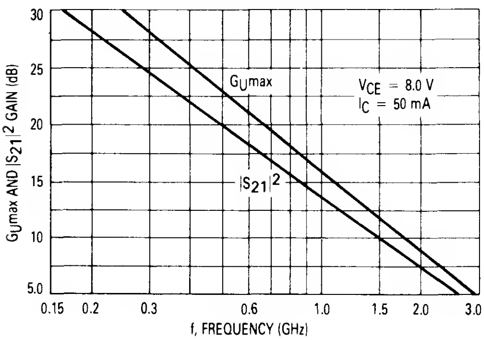
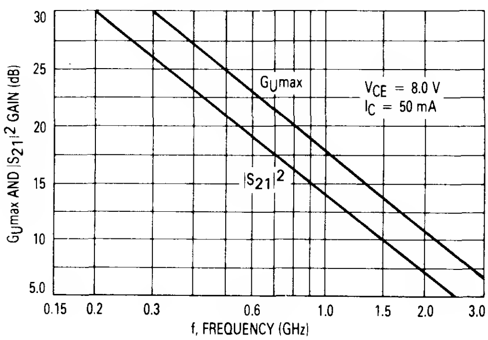
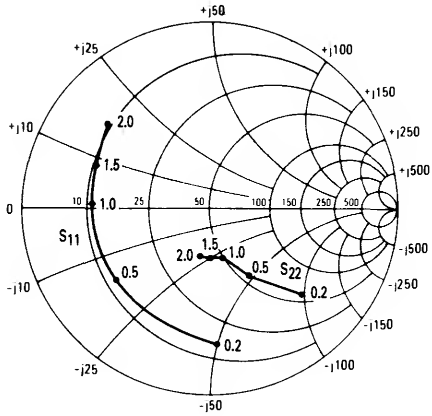


FIGURE 10 — MRF572, MRF573 — $G_U$max and $|S_{21}|^2$ versus FREQUENCY

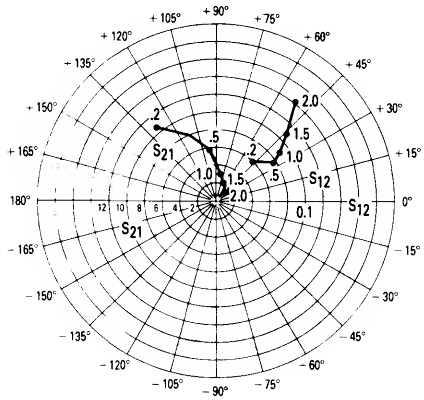


7

MRF571
INPUT/OUTPUT REFLECTION COEFFICIENTS
versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



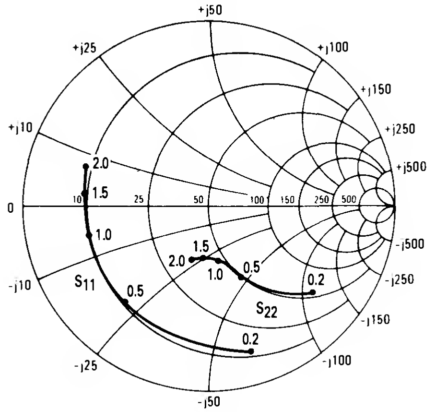
MRF571
FORWARD/REVERSE TRANSMISSION
COEFFICIENTS versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



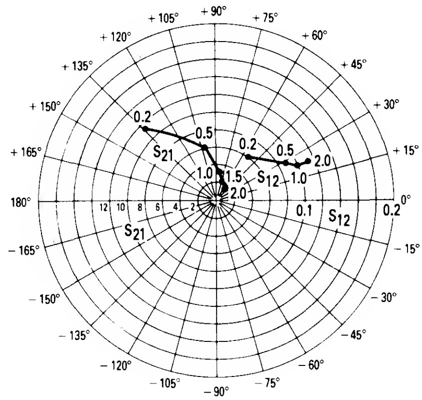
MRF571 COMMON EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11} $\|S_{11}\|$	S_{11} ∠φ	S_{21} $\|S_{21}\|$	S_{21} ∠φ	S_{12} $\|S_{12}\|$	S_{12} ∠φ	S_{22} $\|S_{22}\|$	S_{22} ∠φ
6.0	5.0	200	0.74	−86	10.5	129	0.06	48	0.69	−42
		500	0.62	−143	5.5	97	0.08	33	0.41	−59
		1000	0.61	178	3.0	78	0.09	37	0.28	−69
		1500	0.65	158	2.0	62	0.11	44	0.26	−88
		2000	0.70	140	1.6	51	0.14	51	0.27	−99
	10	200	0.64	−111	15	118	0.04	44	0.53	−59
		500	0.58	−160	6.9	93	0.06	42	0.27	−77
		1000	0.59	168	3.7	77	0.09	52	0.16	−91
		1500	0.63	151	2.5	64	0.12	56	0.16	−113
		2000	0.67	134	2.0	53	0.16	57	0.16	−118
	50	200	0.56	−160	20.4	102	0.02	57	0.27	−98
		500	0.57	176	8.4	86	0.05	67	0.14	−130
		1000	0.60	156	4.4	75	0.09	70	0.11	−164
		1500	0.62	152	2.9	64	0.13	68	0.13	−175
		2000	0.66	127	2.4	53	0.18	62	0.11	−178
8.0	5.0	200	0.75	−83	10.7	129	0.06	49	0.71	−39
		500	0.62	−140	5.1	98	0.08	34	0.43	−54
		1000	0.60	−179	3.7	78	0.09	38	0.31	−62
		1500	0.64	159	2.1	62	0.10	45	0.29	−80
		2000	0.69	141	1.7	52	0.13	52	0.29	−91
	10	200	0.64	−99	15.1	120	0.05	46	0.54	−60
		500	0.52	−152	7.1	94	0.07	45	0.32	−75
		1000	0.52	170	3.7	76	0.10	54	0.15	−82
		1500	0.52	150	2.5	62	0.13	56	0.16	−108
		2000	0.57	133	2.0	51	0.18	55	0.16	−107
	50	200	0.52	−153	19.6	102	0.03	56	0.28	−92
		500	0.52	178	8.1	86	0.05	67	0.16	−98
		1000	0.56	157	4.1	73	0.10	70	0.06	−130
		1500	0.54	139	2.8	62	0.13	68	0.11	−146
		2000	0.59	126	2.2	52	0.19	63	0.10	−137

MRF572
INPUT/OUTPUT REFLECTION
COEFFICIENTS versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



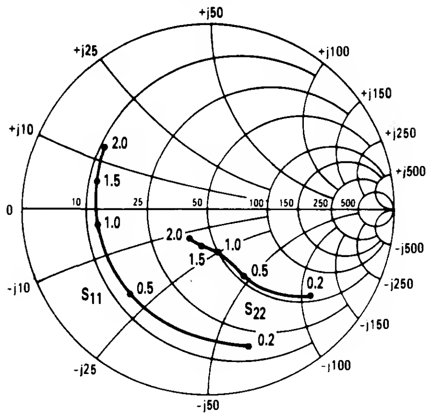
MRF572
FORWARD/REVERSE COEFFICIENTS
versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



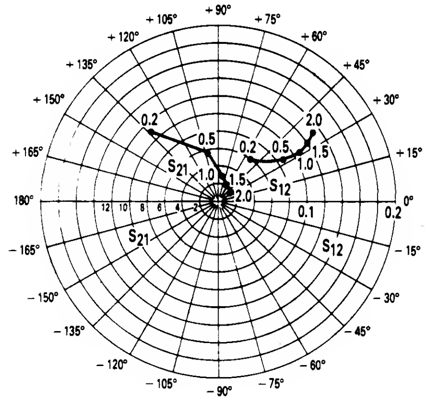
MRF572 COMMON EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
6.0	5.0	200	0.81	−73	10.9	134	0.06	50	0.74	−40
		500	0.68	−130	6.1	102	0.09	29	0.43	−64
		1000	0.66	−167	3.3	79	0.10	22	0.29	−77
		1500	0.66	174	2.3	63	0.10	22	0.27	−94
		2000	0.68	161	1.8	49	0.11	23	0.29	−104
	10	200	0.72	−101	15.9	123	0.05	43	0.57	−58
		500	0.66	−150	7.7	95	0.06	30	0.29	−86
		1000	0.66	−178	4.0	77	0.08	33	0.19	−103
		1500	0.67	166	2.7	63	0.09	36	0.19	−122
		2000	0.69	155	2.1	51	0.10	37	0.20	−129
	50	200	0.67	−154	21.8	104	0.02	43	0.30	−94
		500	0.68	−177	9.0	87	0.03	52	0.17	−129
		1000	0.70	167	4.5	74	0.06	58	0.14	−151
		1500	0.71	157	3.0	62	0.08	59	0.16	−160
		2000	0.73	148	2.3	51	0.10	55	0.17	−161
8.0	5.0	200	0.83	−69	10.9	136	0.06	52	0.75	−36
		500	0.71	−125	6.3	103	0.08	30	0.46	−57
		1000	0.64	−164	3.5	80	0.09	24	0.31	−68
		1500	0.65	176	2.4	63	0.10	23	0.29	−84
		2000	0.66	163	1.8	49	0.11	24	0.30	−94
	10	200	0.74	−94	16.2	125	0.05	45	0.60	−51
		500	0.65	−146	7.9	96	0.06	32	0.31	−74
		1000	0.64	−176	4.2	77	0.07	33	0.20	−87
		1500	0.65	168	2.8	63	0.09	36	0.19	−104
		2000	0.67	156	2.2	50	0.10	37	0.20	−111
	50	200	0.62	−150	22.7	104	0.02	43	0.30	−81
		500	0.64	−174	9.4	86	0.03	51	0.15	−107
		1000	0.68	167	4.8	74	0.05	58	0.10	−126
		1500	0.69	160	3.2	61	0.07	58	0.13	−140
		2000	0.70	147	2.4	50	0.09	55	0.15	−140

MRF573
INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



MRF573
FORWARD/REVERSE COEFFICIENTS versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA

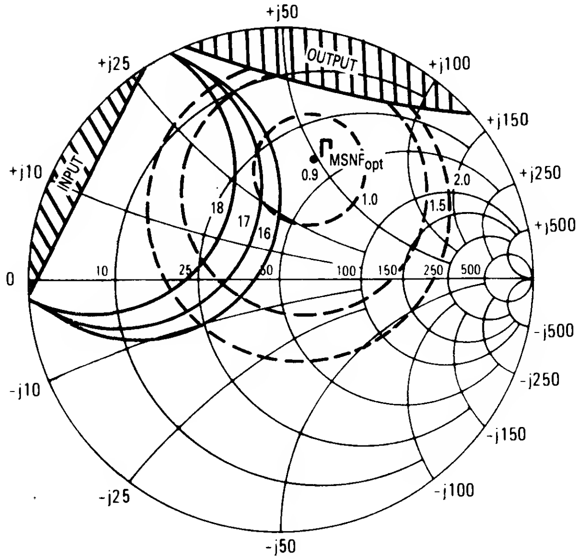


MRF573 COMMON EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11} $\|S_{11}\|$	S_{11} $\angle\phi$	S_{21} $\|S_{21}\|$	S_{21} $\angle\phi$	S_{12} $\|S_{12}\|$	S_{12} $\angle\phi$	S_{22} $\|S_{22}\|$	S_{22} $\angle\phi$
6.0	5.0	200	0.76	−73	10.6	134	0.06	52	0.72	−40
		500	0.61	−132	6.0	100	0.09	35	0.41	−63
		1000	0.59	−173	3.2	77	0.11	33	0.24	−76
		1500	0.61	165	2.2	59	0.12	35	.0.19	−99
		2000	0.64	149	1.8	45	0.13	36	0.18	−117
	10	200	0.64	−99	15.1	122	0.05	48	0.56	−55
		500	0.58	−152	7.2	94	0.07	41	0.27	−81
		1000	0.58	175	3.8	74	0.09	45	0.14	−102
		1500	0.60	158	2.6	60	0.12	47	0.13	−135
		2000	0.64	144	2.0	46	0.13	45	0.13	−155
	50	200	0.54	−153	19.6	104	0.03	55	0.29	−83
		500	0.56	−179	8.1	85	0.05	62	0.13	−115
		1000	0.59	162	4.1	71	0.09	63	0.08	−157
		1500	0.61	150	2.8	58	0.12	60	0.12	179
		2000	0.65	138	2.1	46	0.13	54	0.14	165
8.0	5.0	200	0.78	−67	10.6	136	0.06	54	0.75	−36
		500	0.61	−125	6.1	102	0.09	36	0.44	−56
		1000	0.57	−169	3.4	78	0.10	33	0.27	−66
		1500	0.59	168	2.3	60	0.12	35	0.21	−84
		2000	0.62	151	1.8	46	0.14	36	0.19	−100
	10	200	0.66	−92	15.3	125	0.05	49	0.60	−49
		500	0.55	−147	7.5	95	0.07	41	0.30	−70
		1000	0.55	178	3.9	75	0.09	45	0.16	−81
		1500	0.57	160	2.7	60	0.12	47	0.12	−109
		2000	0.62	146	2.1	47	0.13	45	0.11	−130
	50	200	0.53	−147	20.8	105	0.02	47	0.31	−73
		500	0.53	−176	9.0	87	0.04	57	0.16	−90
		1000	0.57	166	4.5	72	0.07	61	0.06	−110
		1500	0.59	151	3.1	61	0.11	59	0.07	−154
		2000	0.63	143	2.3	49	0.13	55	0.09	−172

7

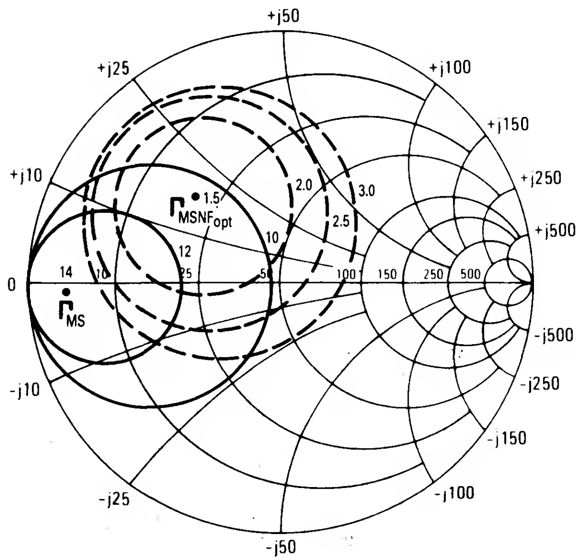
MRF571 — CONSTANT GAIN and NOISE FIGURE CONTOURS



V_{CE} = 6.0 V, I_C = 5.0 mA
f = 500 MHz
— REGION OF INSTABILITY

f(GHz)	NF_{OPT}(dB)	Rn (Ω)	NF50 Ω (dB)
0.5	0.9	9.3	1.3

$\Gamma msNF_{OPT}$	K
0.49 ∠74°	0.58

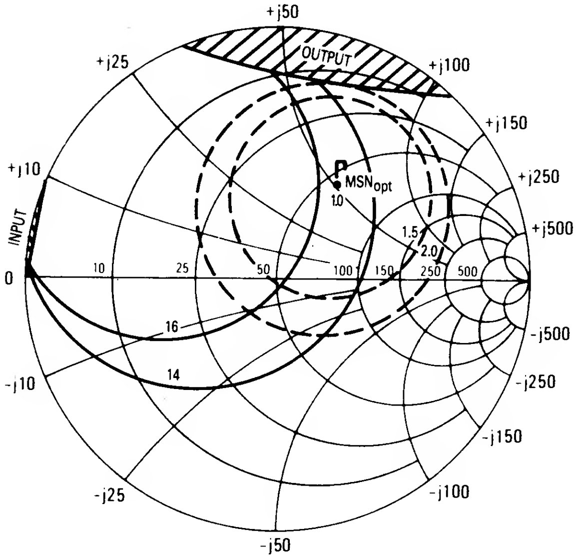


V_{CE} = 6.0 V, I_C = 5.0 mA
f = 1.0 GHz

f(GHz)	NF_{OPT}(dB)	Rn (Ω)	NF50 Ω (dB)	$\Gamma msNF_{OPT}$
1.0	1.5	7.5	2.2	0.48 ∠134°

Γms	ΓmL
0.89 ∠ −179°	0.81 ∠66°

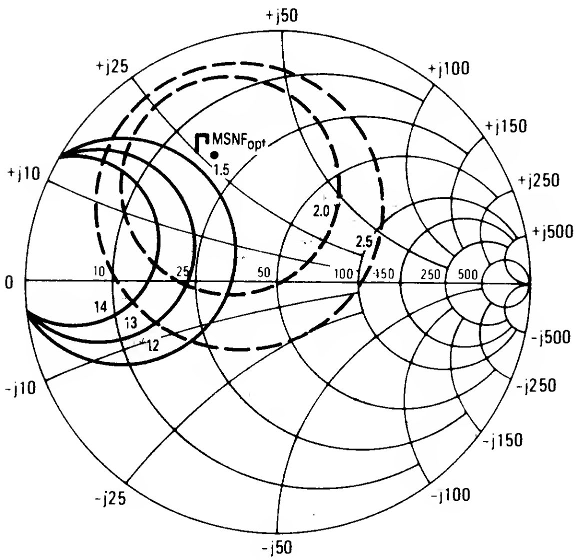
MRF572, MRF573 — CONSTANT GAIN and NOISE FIGURE CONTOURS



V_{CE} = 6.0 V, I = 5.0 mA
f = 500 MHz
— REGION OF INSTABILITY

f(GHz)	Rn (Ω)	NF (50Ω)	ΓmsNF$_{OPT}$
0.5	17.1	1.5	0.43 ∠ 57°

K	NF$_{OPT}$
0.55	1.0



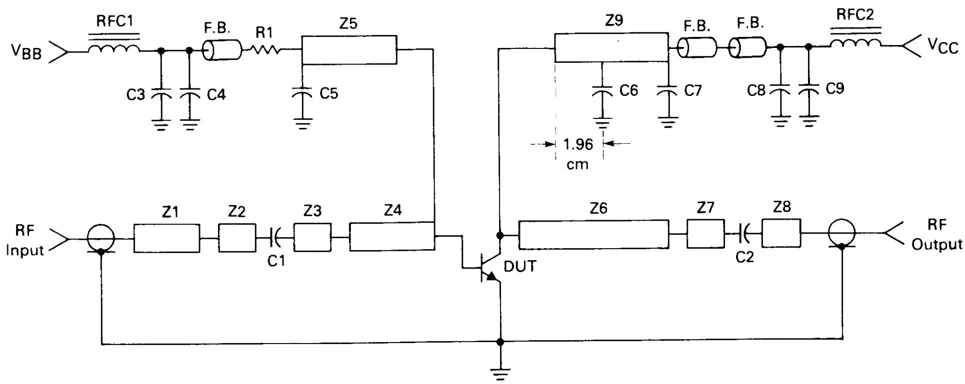
V_{CE} = 6.0 V, I_C = 5.0 mA
f = 1.0 GHz

f(GHz)	NF$_{OPT}$	Rn (Ω)	NF50 (Ω) (dB)
1.0	1.5	6.0	2.0

ΓmsNF$_{OPT}$	K
0.56 ∠ 116°	0.93

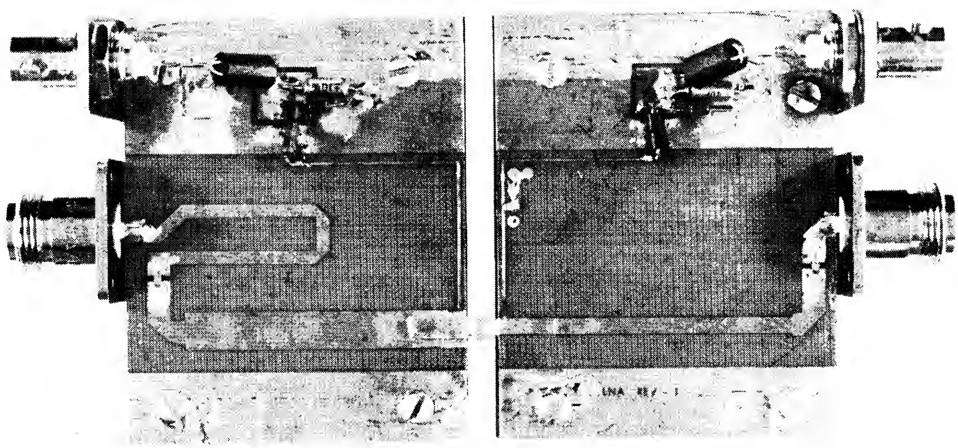
7

MRF571 1.0 GHz TEST CIRCUIT

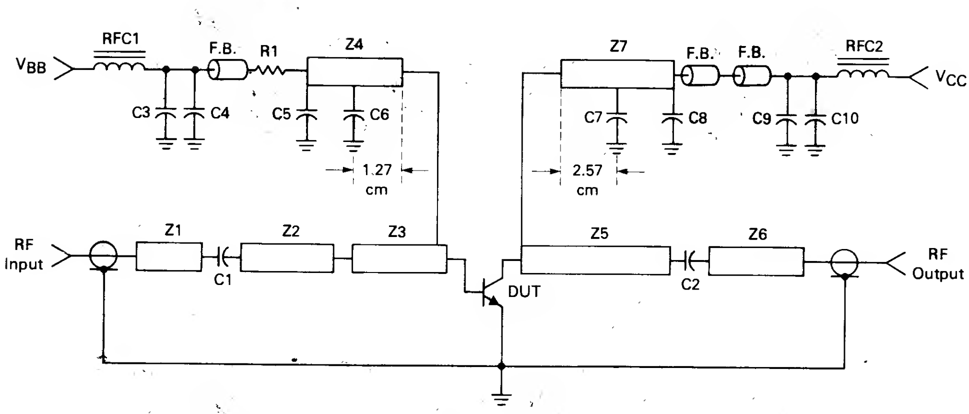


C1, C2, C6	560 pF Chip Capacitor	RFC1, RFC2	VK-200, Ferroxcube
C5, C7	0.018 μF Chip Capacitor	Z1–Z9	Microstrip, See Photomaster
C3, C8	0.1 μF Mylar Capacitor	Bead	Ferrite Bead, Ferroxcube 56-590-65/3B
C4, C9	1.0 μF Electrolytic Capacitor	Board Material	0.0625″ Teflon Fiberglass ϵ_r = 2.5 ± 0.05
R1	2.7 kΩ		

MRF571 TEST CIRCUIT

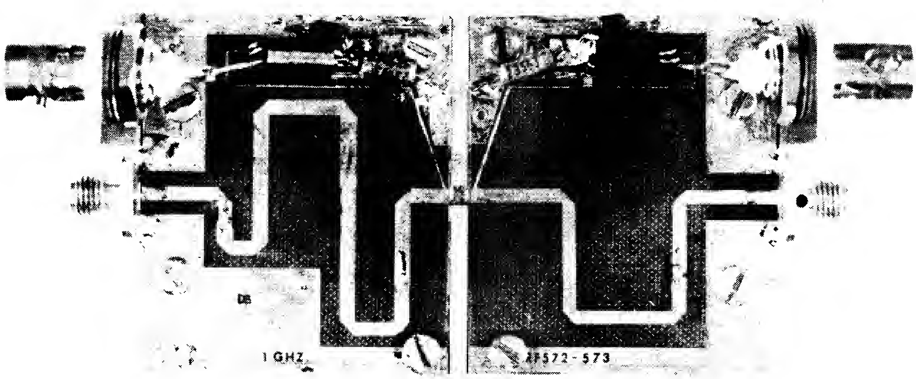


MRF572, 573 1.0 GHz TEST FIXTURE

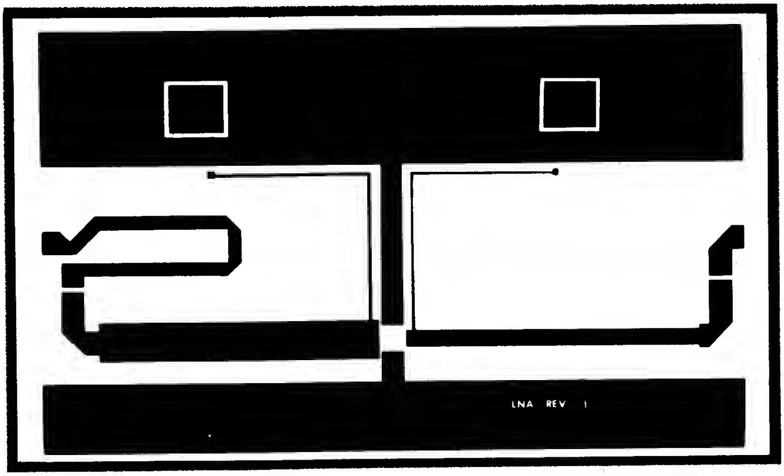


C1, C2, C6, C7	560 pF Chip Capacitor	RFC1, RFC2	VK-200, Ferroxcube
C5, C8	0.018 μF Chip Capacitor	Z1–Z7	Microstrip, See Photomaster
C3, C9	0.1 μF Mylar Capacitor	Bead	Ferrite Bead, Ferroxcube 56-590-65/3B
C4, C10	1.0 μF Electrolytic Capacitor	Board Material	0.031″ Teflon Fiberglass $\epsilon_r = 2.5 \pm 0.05$
R1	2.7 kΩ		

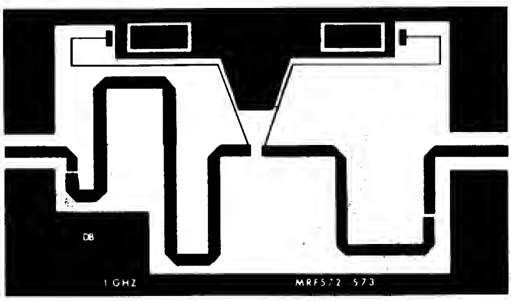
MRF572, 573 TEST CIRCUIT



PHOTOMASTER OF MRF571 CIRCUIT LAYOUT



PHOTOMASTER OF MRF572, 573 CIRCUIT LAYOUT



MRF580

CASE 317A-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MRF581

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MRF581	MRF581	Unit
Collector-Emitter Voltage	V_{CEO}	18	18	Vdc
Collector-Base Voltage	V_{CBO}	36	36	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	2.5	Vdc
Collector Current — Continuous	I_C	200	200	mAdc
Total Device Dissipation @ T_C = 50°C(1) Derate above T_C = 50°C	P_D	2.5 25	2.5 25	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	−65 to +150	°C

(1) Case temperature measured on collector lead immediately adjacent to body of package.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.10 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	100	μAdc
Emitter Cutoff Current (V_{CE} = 2.0 Vdc, V_{BE} = 0)	I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	—	200	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 75 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	f_T	—	5.0	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	1.4	2.0	pF
FUNCTIONAL TESTS					
Noise Figure MRF580/581 (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) Figure 18	NF	—	2.0	3.0	dB
Power Gain at Optimum Noise Figure MRF580 (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) Figure 18	G_{NF}	11	14	—	dB
Power Gain at Optimum Noise Figure MRF581 (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) Figure 18	G_{NF}	13	15.5	—	dB
Maximum Available Power Gain MRF580(2) (I_C = 75 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	G_{max}	—	15	—	dB
Maximum Available Power Gain MRF581(2) (I_C = 75 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	G_{max}	—	17.5	—	dB
Intermodulation Distortion MRF581(3) (V_{CE} = 10 V, I_C = 75 mA, V_{out} = +50 dBmV) Figure 16	IMD(d3)	—	−65	—	dB

(1) 300 μs pulse on Tektronix 576 or equivalent.
(2) Characterized on HP8542 Automatic Network Analyzer.
(3) 2 Tones, f1 = 497 MHz, f2 = 503 MHz, 3rd Order Single Tone reference.

FIGURE 1 — C_{ib} INPUT CAPACITANCE versus VOLTAGE

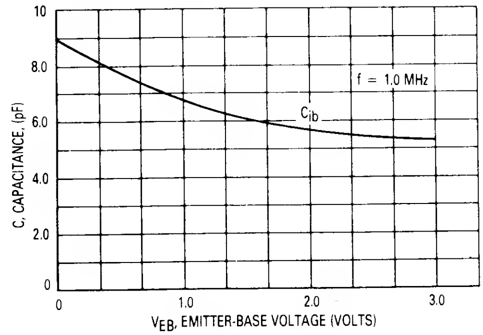


FIGURE 2 — C_{cb}, C_{ob} COLLECTOR-BASE CAPACITANCE versus VOLTAGE

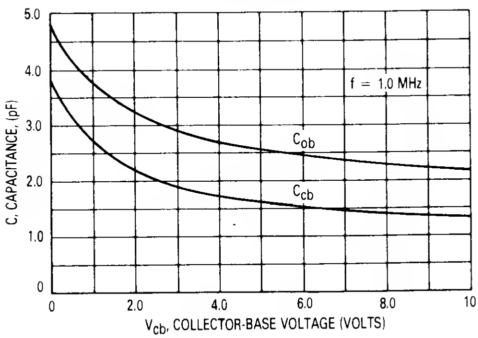


FIGURE 3 — GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

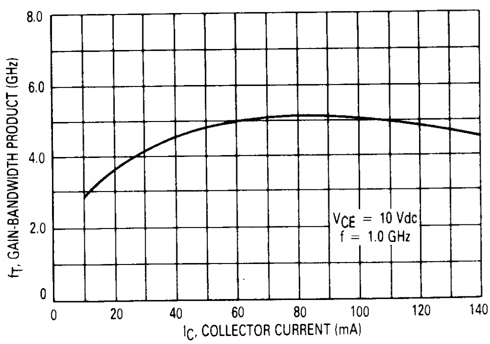
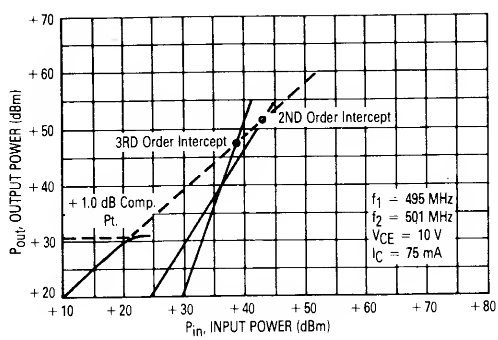


FIGURE 4 — 2ND AND 3RD ORDER INTERCEPT POINTS



MRF580 TYPICAL PERFORMANCE

FIGURE 5 — $G_{U\ max}$-MAXIMUM UNILATERAL GAIN, $|S_{21}|^2$ versus FREQUENCY

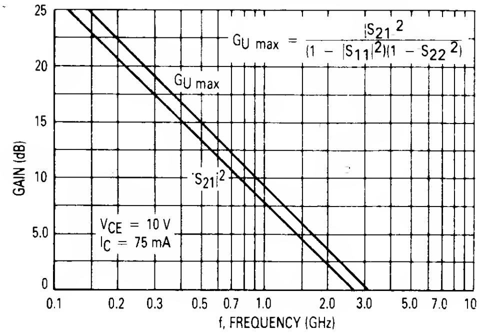


FIGURE 6 — $G_{A\ max}$, MAXIMUM AVAILABLE GAIN versus FREQUENCY

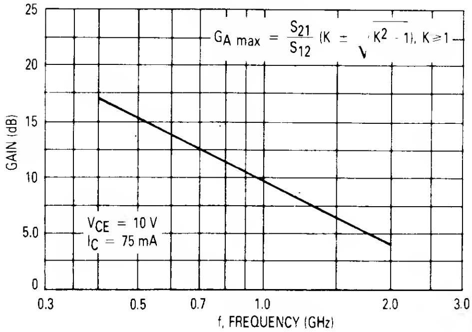


FIGURE 7 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus FREQUENCY

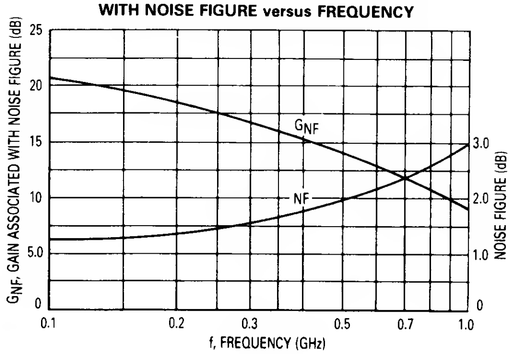


FIGURE 8 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus COLLECTOR CURRENT

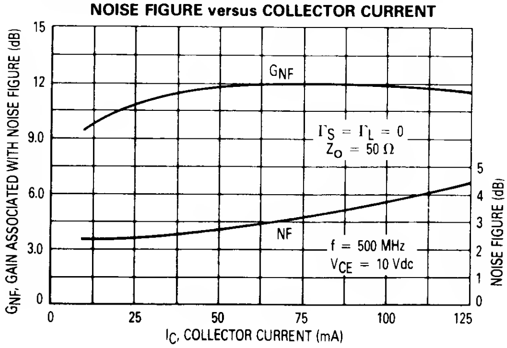
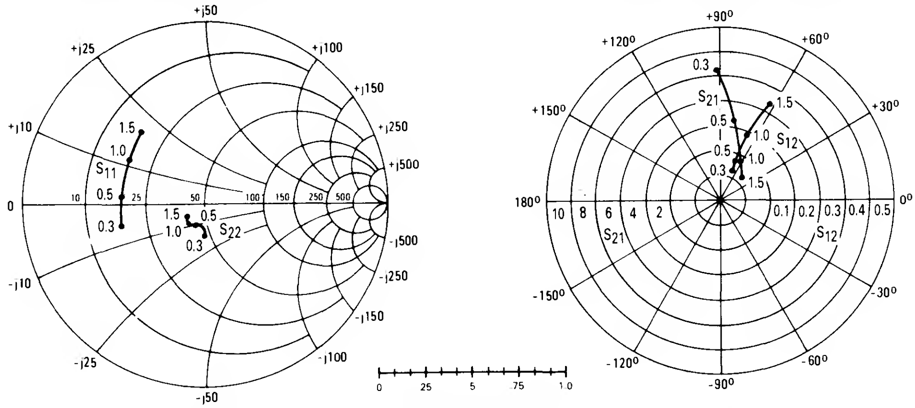


FIGURE 9 — MRF580 COMMON EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENT versus FREQUENCY V_{CE} = 10 V I_C = 50 mA **FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY**



V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11} $\lvert S_{11}\rvert$	S_{11} $\angle\phi$	S_{21} $\lvert S_{21}\rvert$	S_{21} $\angle\phi$	S_{12} $\lvert S_{12}\rvert$	S_{12} $\angle\phi$	S_{22} $\lvert S_{22}\rvert$	S_{22} $\angle\phi$
5.0	25	300	0.49	−170	5.97	91	0.083	60	0.24	−108
		500	0.52	171	3.63	78	0.127	64	0.18	−117
		1000	0.53	149	1.98	58	0.24	66	0.13	−154
		1500	0.56	125	1.46	44	0.35	60	0.19	−172
	50	300	0.48	−175	6.35	90	0.08	64	0.24	−126
		500	0.51	168	3.85	79	0.13	67	0.18	−139
		1000	0.51	148	2.10	59	0.25	66	0.16	−178
		1500	0.54	123	1.56	46	0.36	58	0.20	169
	75	300	0.48	−177	6.42	90	0.08	65	0.24	−132
		500	0.51	167	3.88	79	0.13	67	0.19	−145
		1000	0.50	147	2.12	59	0.26	65	0.17	175
		1500	0.53	123	1.57	46	0.36	58	0.21	164
	100	300	0.48	−177	6.41	89	0.08	66	0.24	−134
		500	0.51	167	3.87	78	0.13	68	0.19	−148
		1000	0.51	146	2.114	59	0.26	65	0.17	172
		1500	0.53	123	1.58	46	0.36	58	0.21	162
10	25	300	0.44	−164	6.67	92	0.07	61	0.25	−76
		500	0.47	175	4.08	79	0.11	66	0.19	−75
		1000	0.48	152	2.2	60	0.21	68	0.12	−91
		1500	0.52	126	1.56	45	0.32	64	0.15	−129
	50	300	0.47	−167	7.40	91	0.07	65	0.17	−89
		500	0.47	174	4.53	79	0.11	68	0.12	−112
		1000	0.50	149	2.38	62	0.20	67	0.13	−126
		1500	0.53	131	1.71	47	0.31	63	0.11	−147
	75	300	0.41	−171	7.24	91	0.07	66	0.20	−96
		500	0.45	171	4.39	79	0.12	69	0.13	−99
		1000	0.45	150	2.36	61	0.23	67	0.07	−130
		1500	0.48	125	1.72	47	0.33	61	0.12	−157
	100	300	0.42	−172	7.22	90	0.07	67	0.19	−97
		500	0.45	170	4.38	78	0.12	69	0.14	−98
		1000	0.45	149	2.35	60	0.23	67	0.07	−129
		1500	0.49	125	1.71	46	0.33	62	0.11	−158
15	25	300	0.48	−159	7.28	93	0.06	60	0.24	−55
		500	0.48	−179	4.44	80	0.09	66	0.17	−62
		1000	0.51	153	2.33	62	0.18	68	0.19	−82
		1500	0.54	133	1.67	46	0.27	68	0.17	−97
	50	300	0.39	−165	7.49	0.92	0.07	65	0.23	−71
		500	0.42	174	4.57	80	0.11	69	0.18	−67
		1000	0.43	152	2.44	61	0.21	68	0.11	−74
		1500	0.46	126	1.76	47	0.31	64	0.12	−115
	75	300	0.39	−167	7.57	91	0.07	66	0.21	−74
		500	0.42	173	4.57	79	0.11	70	0.17	−69
		1000	0.42	151	2.45	61	0.21	68	0.09	−75
		1500	0.46	126	1.76	46	0.31	64	0.11	−118
	100	300	0.39	−168	7.46	90	0.07	67	0.20	−72
		500	0.43	172	4.53	78	0.11	70	0.17	−66
		1000	0.43	151	2.41	60	0.21	69	0.10	−71
		1500	0.47	126	1.74	46	0.31	64	0.12	−113

MRF581 TYPICAL PERFORMANCE

FIGURE 10 — $G_{U\ max}$ — MAXIMUM UNILATERAL GAIN, $|S_{21}|^2$ versus FREQUENCY

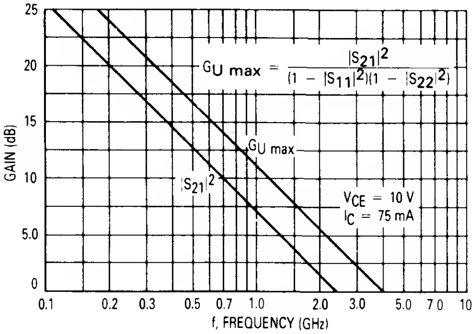


FIGURE 11 — $G_{A\ max}$, MAXIMUM AVAILABLE GAIN versus FREQUENCY

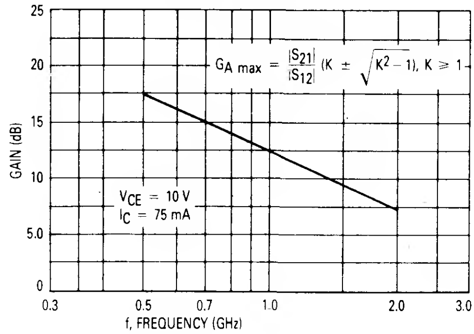


FIGURE 12 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus FREQUENCY

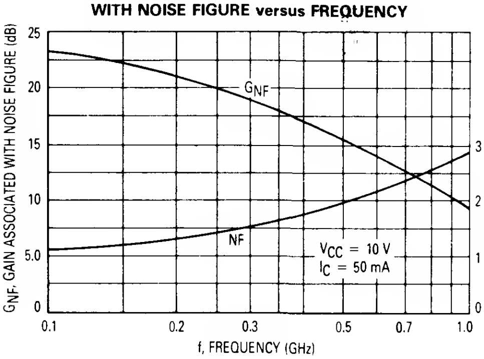


FIGURE 13 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus COLLECTOR CURRENT

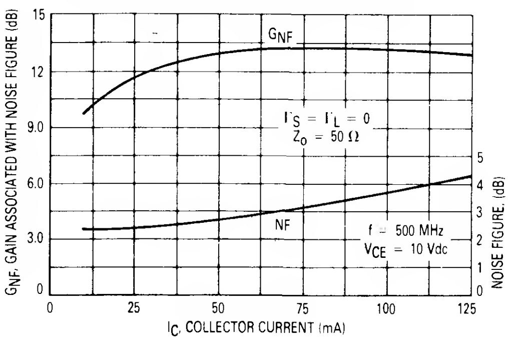


FIGURE 14 — OUTPUT POWER versus INPUT POWER f = 470 MHz

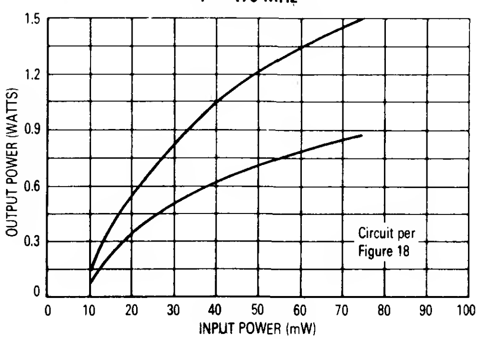


FIGURE 15 — OUTPUT POWER versus INPUT POWER f = 870 MHz

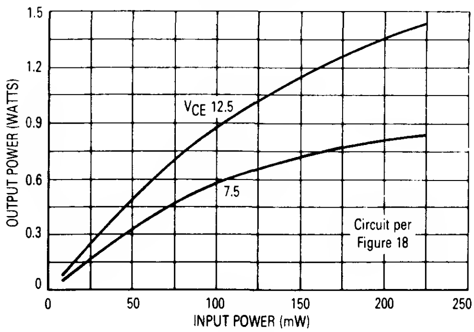


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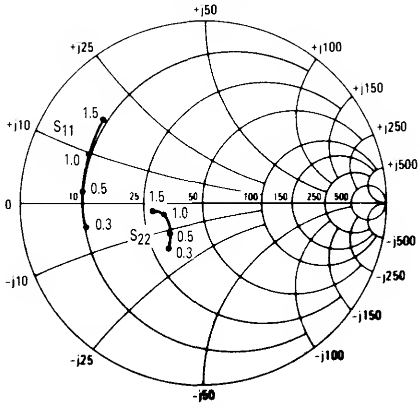
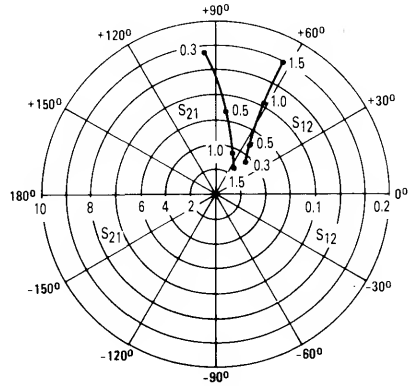
FIGURE 16 — MRF581 COMMON EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

V_{CE} = 10 V, I_C = 50 mA

FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY





V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11} $\|S_{11}\|$	$\angle\phi$	S_{21} S_{21}	$\angle\phi$	S_{12} $\|S_{12}\|$	$\angle\phi$	S_{22} S_{22}	$\angle\phi$
5.0	25	300	0.69	-169	6.57	93	0.06	39	0.34	-129
		500	0.72	176	3.95	82	0.07	47	0.29	-142
		1000	0.73	157	2.10	62	0.12	60	0.27	-165
		1500	0.76	139	1.47	50	0.17	61	0.33	172
	50	300	0.70	-173	7.14	93	0.05	45	0.38	-144
		500	0.72	173	4.27	82	0.07	53	0.34	157
		1000	0.72	157	2.24	65	0.13	62	0.33	179
		1500	0.76	138	1.61	53	0.18	61	0.37	173
	75	300	0.70	-175	7.26	92	0.05	48	0.40	-148
		500	0.72	172	4.33	82	0.07	55	0.36	-161
		1000	0.72	155	2.28	65	0.13	63	0.35	176
		1500	0.76	138	1.64	53	0.19	61	0.39	170
	100	300	0.70	-176	7.30	92	0.05	48	0.40	-151
		500	0.72	172	4.34	82	0.07	56	0.37	-163
		1000	0.72	155	2.28	65	0.13	63	0.362	175
		1500	0.75	137	1.64	53	0.19	61	0.39	168
10	25	300	0.66	-165	7.58	95	0.05	40	0.29	-106
		500	0.69	178	4.56	82	0.07	48	0.23	-116
		1000	0.70	159	2.39	64	0.11	61	0.19	-141
		1500	0.74	141	1.65	50	0.16	64	0.26	-153
	50	300	0.65	-169	8.25	94	0.05	46	0.30	126
		500	0.68	175	4.96	82	0.07	54	0.24	-138
		1000	0.69	157	2.60	65	0.12	63	0.22	-164
		1500	0.72	139	1.82	52	0.17	63	0.27	-171
	75	300	0.66	-171	8.49	93	0.05	48	0.30	-132
		500	0.68	175	5.06	82	0.07	55	0.25	-145
		1000	0.69	157	2.64	65	0.12	64	0.23	170
		1500	0.72	139	1.86	53	0.17	63	0.27	-176
	100	300	0.66	-172	8.46	93	0.05	49	0.30	-134
		500	0.68	174	5.06	82	0.07	56	0.25	-147
		1000	0.68	157	2.64	65	0.12	64	0.23	-172
		1500	0.72	139	1.86	52	0.17	63	0.27	-177
15	25	300	0.65	-163	7.96	95	0.05	40	0.28	-92
		500	0.67	179	4.82	82	0.06	48	0.21	-98
		1000	0.68	160	2.51	63	0.10	62	0.17	-119
		1500	0.72	141	1.73	49	0.16	65	0.24	-137
	50	300	0.64	-167	8.76	94	0.0	46	0.26	-112
		500	0.66	177	5.37	82	0.06	54	0.20	-122
		1000	0.67	159	2.75	65	0.11	64	0.16	-148
		1500	0.71	141	1.91	51	0.16	64	0.22	-157
	75	300	0.64	-168	8.93	93	0.05	47	0.25	-117
		500	0.66	176	5.34	82	0.06	55	0.20	-128
		1000	0.69	158	2.78	65	0.11	65	0.16	-154
		1500	0.70	140	1.93	51	0.16	64	0.22	-162
	100	300	0.64	-169	8.91	93	0.05	48	0.25	-117
		500	0.66	176	5.33	82	0.6	56	0.19	-129
		1000	0.67	158	2.78	64	0.11	65	0.16	-154
		1500	0.70	140	1.93	51	0.16	64	0.21	-160

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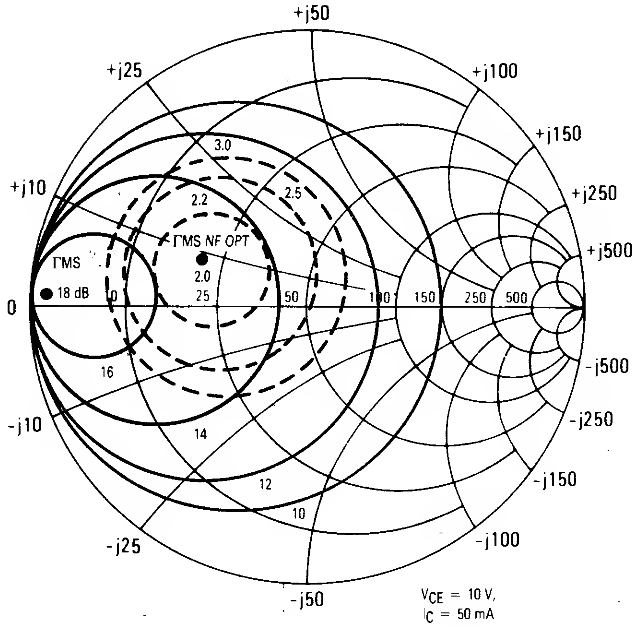
FIGURE 17 — MRF581 CONSTANT GAIN CONTOURS NOISE FIGURE CONTOURS



f(MHz)	ΓMS	ΓML	ΓMS NF OPT	G_{AMAX} (dB)	Rn (Ω)	NF OPT	NF (50 Ω)
500	0.91/176°	0.78/77°	0.39/159°	18	10.5	2.0	2.5

Circuit Per Figure 20

FIGURE 18 — FUNCTIONAL CIRCUIT SCHEMATIC

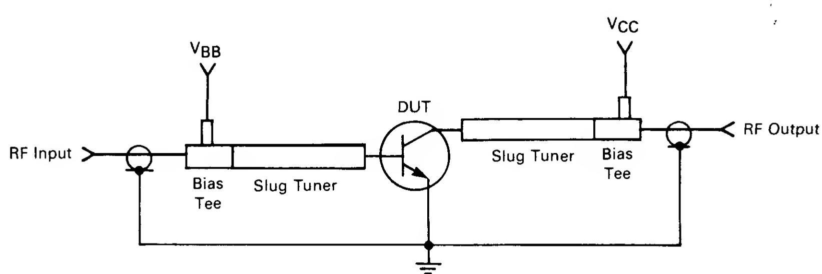
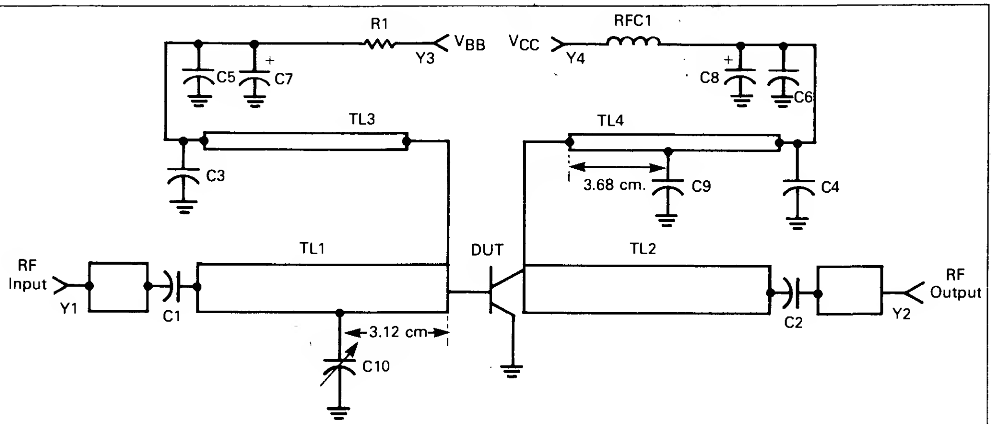


FIGURE 19 — Z_{in} AND Z_{OL} versus COLLECTOR VOLTAGE, INPUT POWER AND FREQUENCY

P_{in} (mW)	f MHz	Z_{in} Ohms 7.5 V	Z_{in} Ohms 12.5 V	Z_{OL}* Ohms 7.5 V	Z_{OL}* Ohms 12.5 V
50	420	9.8 − j12.0	10.3 − j11.1	27.5 − j2.7	54.5 + j5.7
	470	14.2 − j11.1	10.2 − j10.2	28.6 − j2.9	30.8 − j26.3
	520	13.6 − j8.6	8.2 − j7.7	27.0 − j5.0	30.4 − j26.0
75	806	7.6 + j1.3	7.7 + j0.8	16.4 − j22.7	22.3 − j34.0
	870	7.7 − j1.7	7.7 − j2.1	18.4 − j19.2	25.1 − j28.1
	960	6.0 + j4.3	5.9 + j2.5	21 − j17.1	24.5 − j20.4

*Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

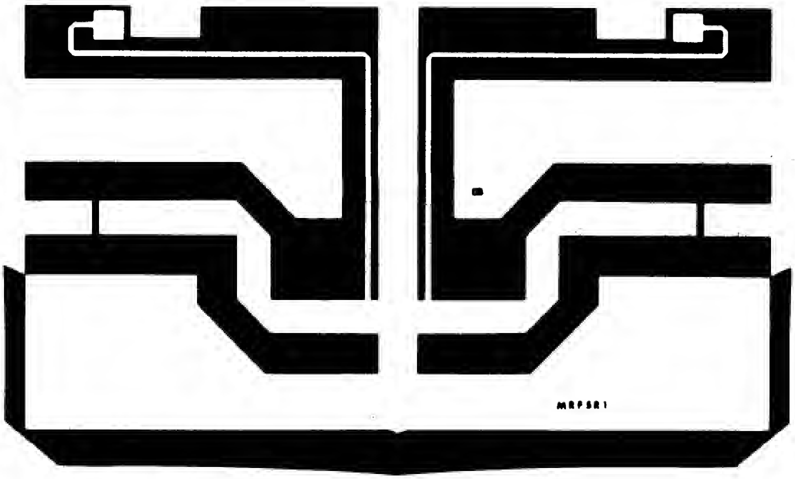
FIGURE 20 — MRF580/581 TEST FIXTURE SCHEMATIC
500 MHz

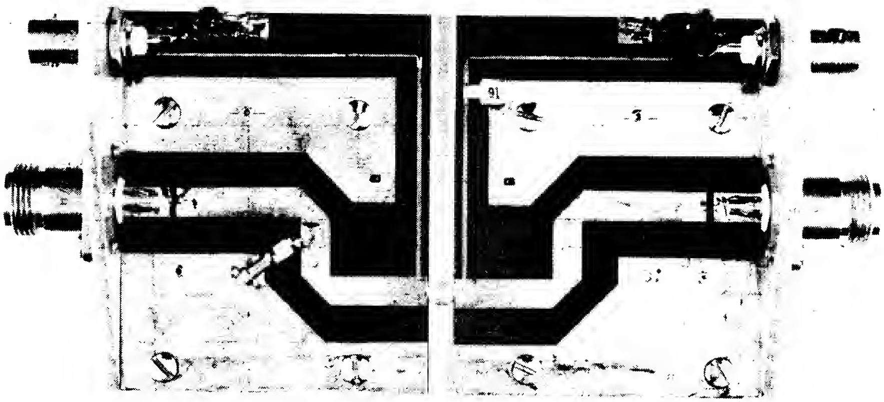


C1, C2 — 470 pF Chip (Ceramic)
C3, C4 — 0.018 μF Chip Capacitor
C5, C6 — 0.1 μF Mylar
C7, C8 — 1.0 μF, 25 Vdc Electrolytic
C9 — 91 pF Mini-Unelco (C9 Taped 3.68 cm from Collector Connection on TL4 as shown)
C10 — 35–45 pF Johanson Ceramic Capacitor, JMC 5801 or Equivalent (C10 Taped 3.12 cm from Base Connection on TL1)

R1 — 2.7 kΩ, 1½ W
RFC1 — 0.15 μH Molded Choke
TL1, TL2 — Z_0 = 26 Ω, 0.0625 TFG as shown in Photomaster
TL3, TL4 — λ/4 Microstrip, Z_0 = 100 Ω
Y1, Y2 — N-Type Connection (Female)
Y3, Y4 — BNC-Type Connector (Female)
Board Material — 0.0625″ Thick Glass Teflon ϵ_r = 2.5

FIGURE 21 — PC BOARD PHOTOMASTER





MRF604

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

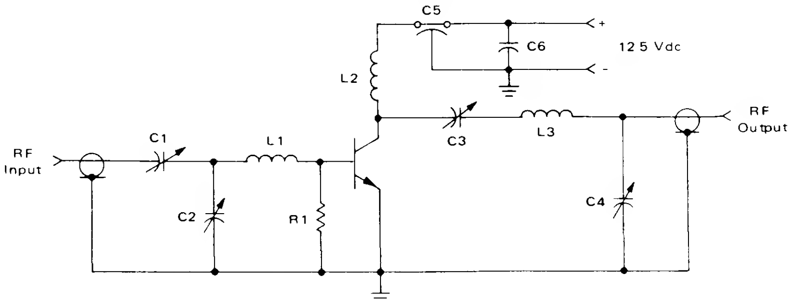
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 0.04	Watts W/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 12$ Vdc, $I_B = 0$)	I_{CEO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20	80	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 200 MHz)	f_T	800	—	—	MHz
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	—	3.5	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5$ Vdc, $P_{out} = 1.0$ W, f = 175 MHz)	G_{PE}	10	—	—	dB
Collector Efficiency ($V_{CC} = 12.5$ Vdc, $P_{out} = 1.0$ W, f = 175 MHz)	η	50	—	—	%
Series Equivalent Input Impedance ($V_{CC} = 12.5$ Vdc, $P_{out} = 1.0$ W, f = 175 MHz)	Z_{in}	—	7.5−j14	—	Ohms
Series Equivalent Output Impedance ($V_{CC} = 12.5$ Vdc, $P_{out} = 1.0$ W, f = 175 MHz)	Z_{out}	—	47−j60	—	Ohms

FIGURE 1 — 175 MHz TEST CIRCUIT SCHEMATIC



C1,C2,C3,C4	3.0 30 pF
C5	1000 pF
C6	0.01 μF
L1	2 Turns, #16 AWG, 3/16" I.D., 1/4" Long
L2	0 15 μH, MOLDED CHOKE
L3	4 Turns, #16 AWG, 3/8" I.D., 3/8" Long
R1	100 Ω, 1/4 W, 10%

FIGURE 2 — OUTPUT POWER versus INPUT POWER

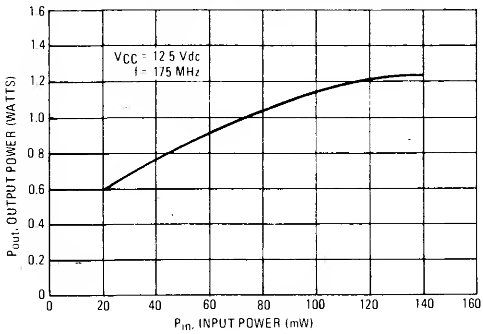


FIGURE 3 — CURRENT-GAIN BANDWIDTH PRODUCT

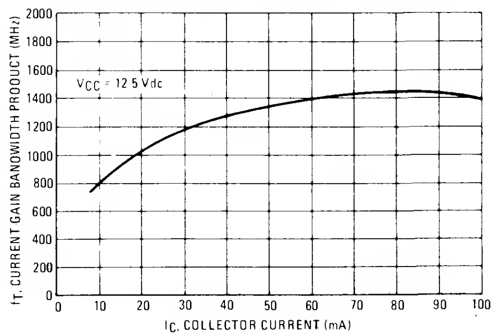
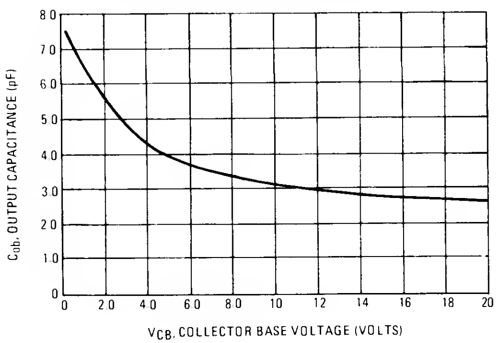


FIGURE 4 — OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE



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MRF607

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

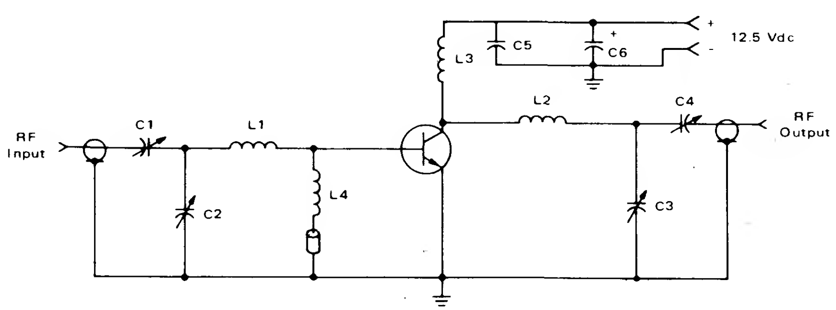
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.33	Adc
Total Device Dissipation @ T_C = 75°C(1) Derate above 75°C	P_D	3.5 28	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.5 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 10 Vdc, I_B = 0)	I_{CEO}	—	0.3	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	150	—
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	15	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain (P_{out} = 1.75 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	11.5	—	dB
Collector Efficiency (P_{out} = 1.75 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	50	—	%

FIGURE 1 – 175 MHz TEST CIRCUIT SCHEMATIC



C1	2.7-15 pF, ARCO 461	L1	1 Turn #20 AWG, 3/8" ID
C2	9.0-180 pF, ARCO 463	L2	3 Turns #20 AWG, 3/8" ID
C3,C4	5.0-80 pF, ARCO 462	L3	0.22 μH Molded Choke
C5	1000 pF UNELCO	L4	0.15 μH Molded Choke with FERROXCUBE 56-590-65-3B Bead on ground lead
C6	5 μF, 25 Vdc, TANTALUM		

TYPICAL PERFORMANCE DATA

FIGURE 2 – OUTPUT POWER versus FREQUENCY

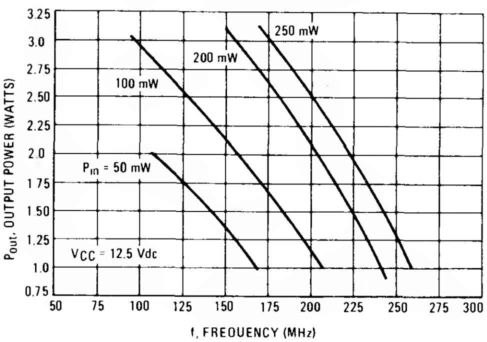


FIGURE 3 – OUTPUT POWER versus INPUT POWER

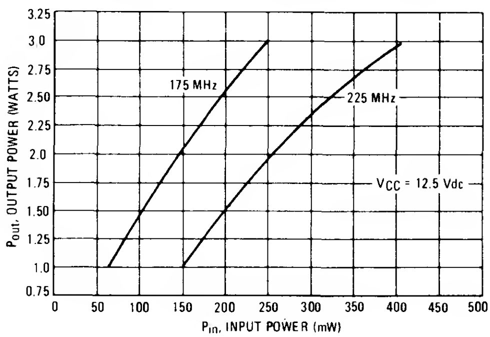


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

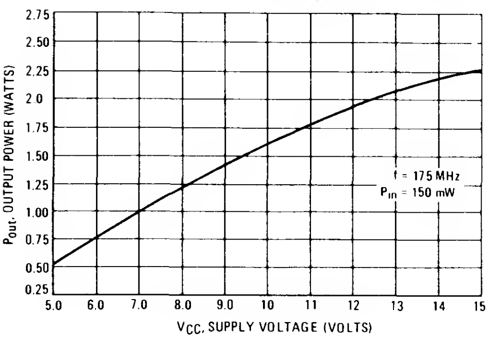
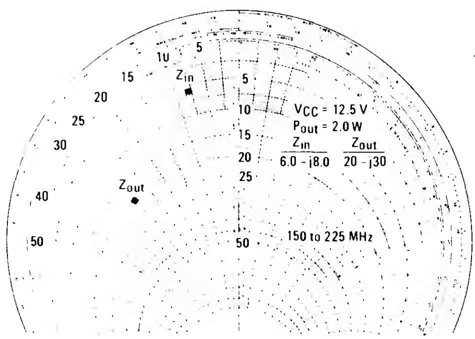


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE PARAMETERS



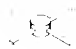
MRF626
MRF627

MRF626
CASE 305-01, STYLE 1

MRF627
CASE 305A-01, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 35	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200°C	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	28.5	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, I_B = 0)	I_{CEO}	—	—	1.0	mAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)	I_{EBO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	15	—	150	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 12.5 Vdc, f = 200 MHz) (I_C = 100 mAdc, V_{CE} = 12.5 Vdc, f = 200 MHz) (I_C = 150 mAdc, V_{CE} = 12.5 Vdc, f = 200 MHz)	f_T	 — — —	 2.5 2.7 2.6	 — — —	GHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	3.5	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	8.8	—	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, f = 470 MHz)	G_{PE}	10	12	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, f = 470 MHz)	η	—	60	—	%
Series Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, f = 470 MHz)	Z_{in}	—	6.0 − j4.0	—	Ohms
Series Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, f = 470 MHz)	Z_{out}	—	45 − j28	—	Ohms

FIGURE 1 – OUTPUT POWER versus INPUT POWER

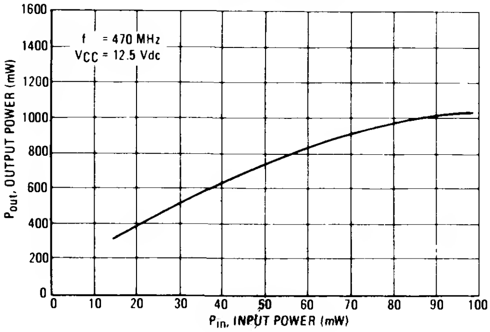


FIGURE 2 – OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE

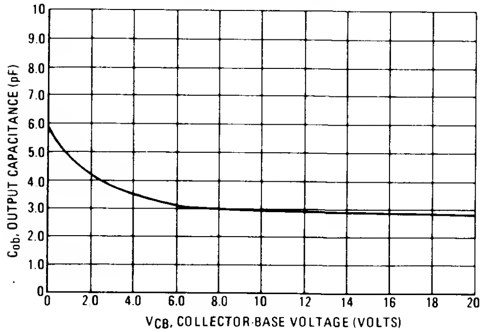
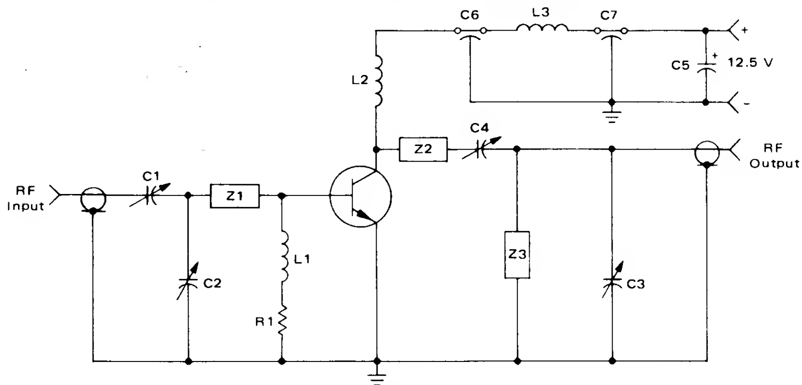


FIGURE 3 – 470 MHz TEST CIRCUIT SCHEMATIC



C1,C2 – 1.0-25 pF ARCO 421
C3,C4 – 1.0-25 pF ARCO 421
C5 – 1.0 μF, 35 V Capacitor
C6,C7 – 1000 pF Feedthru
L1,L2 – 7 Turns, #22 AWG, 0.2" I.D.
L3 – Choke FERROXCUBE VK 200-20-4B
R1 – 1 Ohm, 1/2 W Carbon
Z1 – Microstrip Line, 0.25" W x 1.75 " L
Z2 – Microstrip Line, 0.25" W x 2.00" L
Z3 – Microstrip Line, 0.50" W x 1.00" L
Board-Glass Teflon, 3" x 5" x 0.060"
Mounting Plate is 3" x 5" x 0.75"
Input/Output Connectors – Type N

FIGURE 4 – 470 MHz TEST CIRCUIT LAYOUT

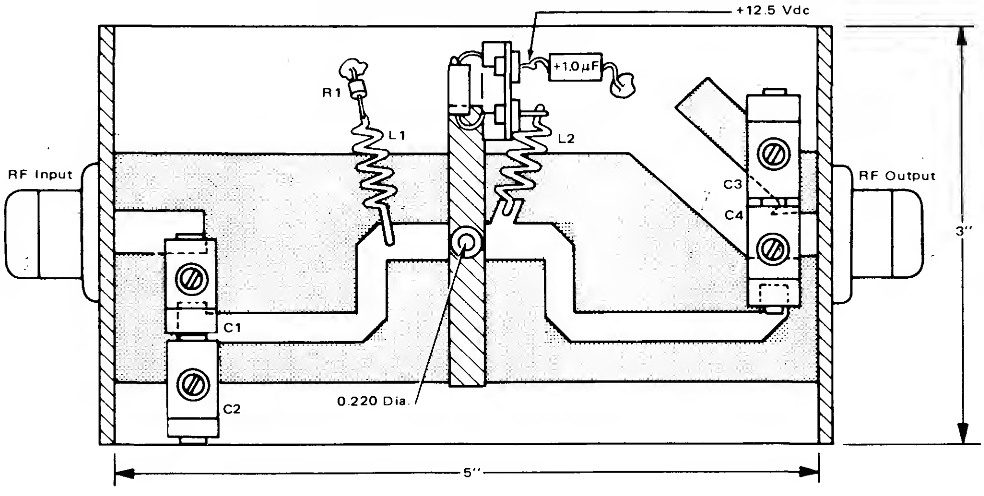


FIGURE 5 – TYPICAL S_{11} and S_{22} versus FREQUENCY

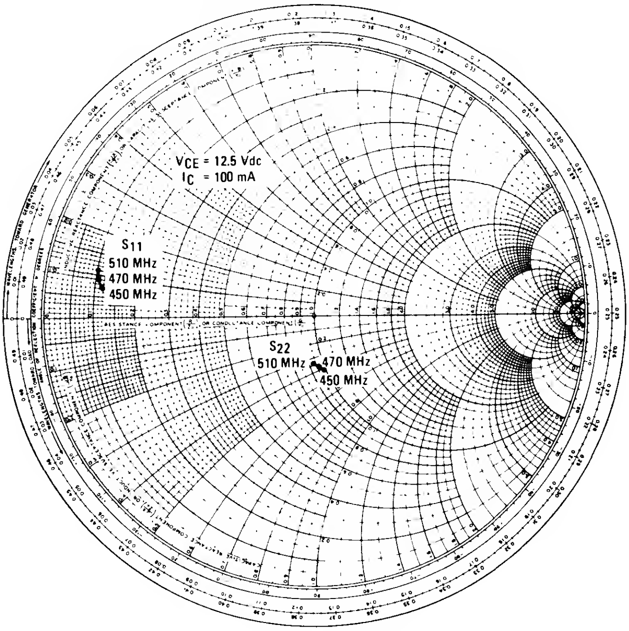


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FIGURE 6 – TYPICAL S_{12} versus FREQUENCY

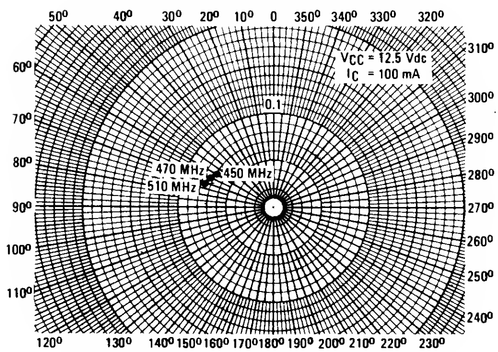
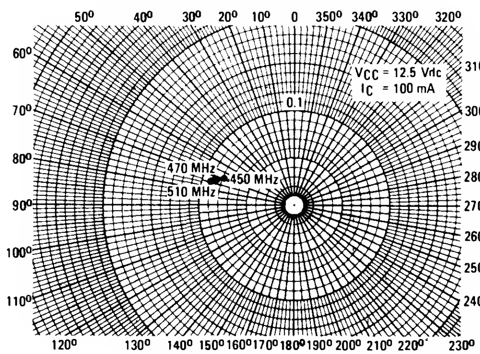


FIGURE 7 – TYPICAL S_{21} versus FREQUENCY

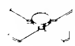


MRF628

CASE 249-05, STYLE 1

UHF AMPLIFIER TRANSISTOR

NPN SILICON



7

MAXIMUM RATINGS

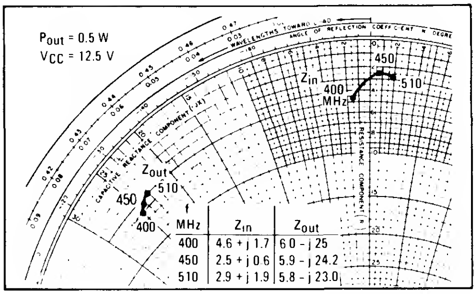
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 20 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_C = 0)	I_{CBO}	—	—	0.5	mAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	10	pF
FUNCTIONAL TEST (FIGURES 5 AND 6)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, I_C(max) = 80 mAdc, f = 470 MHz)	G_{PE}	10	—	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, I_C(max) = 80 mAdc, f = 470 MHz)	η	50	—	—	%

(1) Pulsed thru 25 mH inductor.

FIGURE 1 – SERIES EQUIVALENT IMPEDANCE PARAMETERS



f MHz	Zin	Zout
400	4.6 + j 1.7	6.0 – j 25
450	2.5 + j 0.6	5.9 – j 24.2
510	2.9 + j 1.9	5.8 – j 23.0

FIGURE 2 – OUTPUT POWER versus INPUT POWER

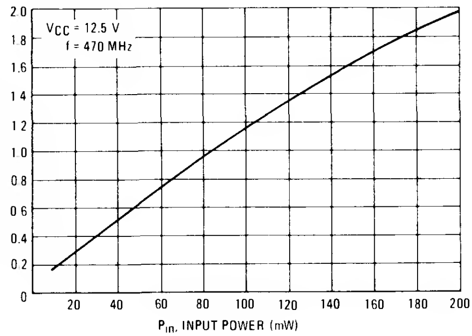


FIGURE 3 – OUTPUT POWER versus FREQUENCY

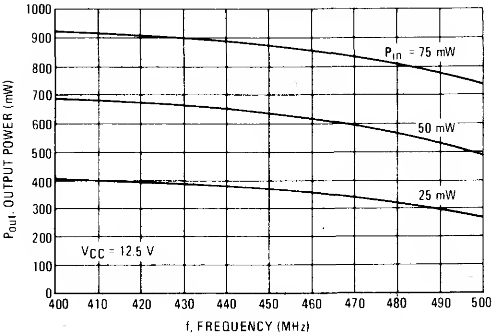


FIGURE 4 – OUTPUT POWER versus VOLTAGE

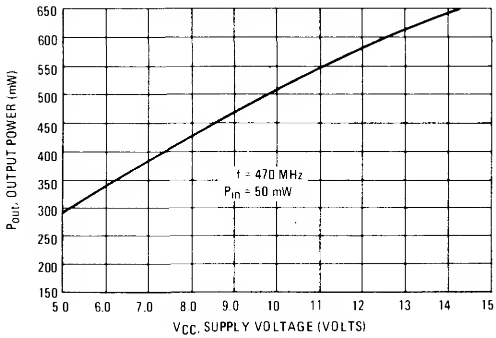


FIGURE 5 – 470 MHz TEST CIRCUIT

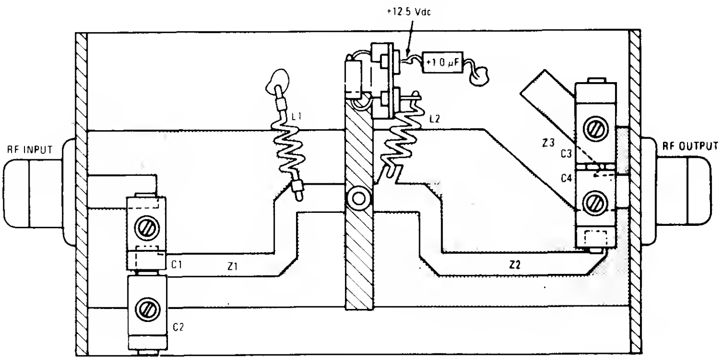
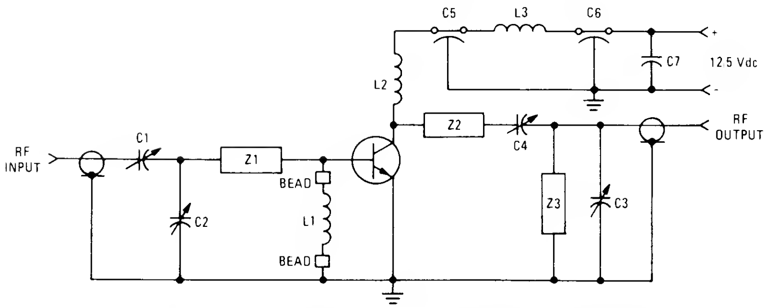


FIGURE 6 – 470 MHz TEST CIRCUIT SCHEMATIC



C1,2,3,4	1.0-25 pF ARCO 421 OR EQUIVALENT
C5,6	1000 pF FEEDTHRU CAPACITOR
C7	1.0 μF, 35 V CAPACITOR
L1,2	7 TURNS #22 AWG, 0.2" I.D. FERRITE BEADS FERROXCUBE 56 590 65 3B AS SHOWN ON L1
L3	1-CHOKE FERROXCUBE VK 200 20 4B

BOARD GLASS TEFLON, ϵ_R = 2.56, t = 0.062
MOUNTING PLATE – 3" x 5" x 0.060"
INPUT/OUTPUT CONNECTORS – TYPE N

7

MRF629

CASE 79-03, STYLE 5

HIGH FREQUENCY TRANSISTOR

NPN SILICON

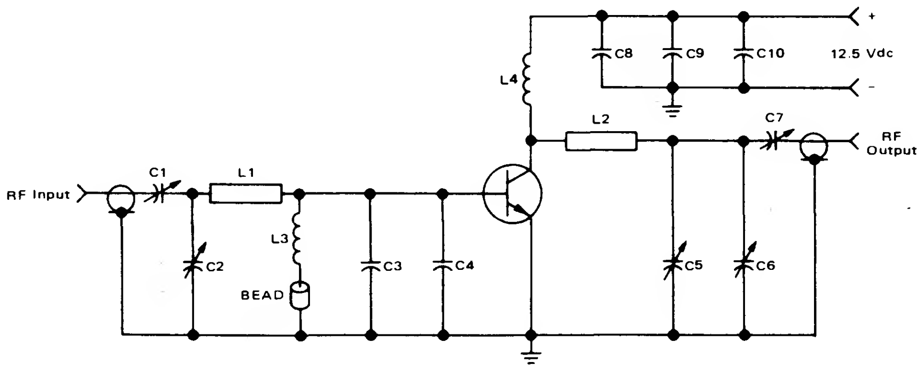
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 50	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 50$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	16	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 50$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20	200	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	15	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5$ Vdc, $P_{out} = 2.0$ W, f = 470 MHz)	G_{PE}	8.0	—	dB
Collector Efficiency ($V_{CC} = 12.5$ Vdc, $P_{out} = 2.0$ W, f = 470 MHz)	η	50	—	%

FIGURE 1 – 470 MHz TEST CIRCUIT SCHEMATIC



C1,C5 – 1.5-20 pF, ARCO 402
C2,C6 – 1-10 pF, JOHANSON 2951
C3 – 15 pF, UNELCO
C4 – 25 pF, UNELCO
C7 – 8.0-60 pF, ARCO 404
C8 – 100 pF, UNELCO
C9 – 0.047 μF ERIE Disc Cap 100 V
C10 – 1.0 μF TANTALUM
L1,L2 – Copper Strap, 1" Length x 0.125" Width x 0.005" Thickness, x 2.54 cm
L3 – 3.3 μH Molded Choke
L4 – 0.15 μH Molded Choke
BEAD – FERROXCUBE 56-590-65-38
INPUT/OUTPUT CONNECTORS – Type BNC

FIGURE 2 – OUTPUT POWER versus INPUT POWER

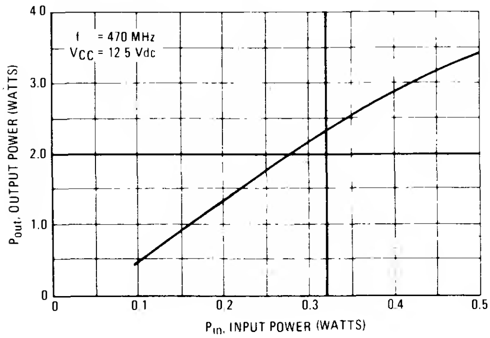


FIGURE 3 – OUTPUT POWER versus FREQUENCY

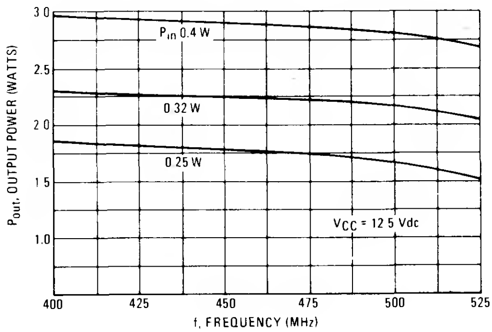


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

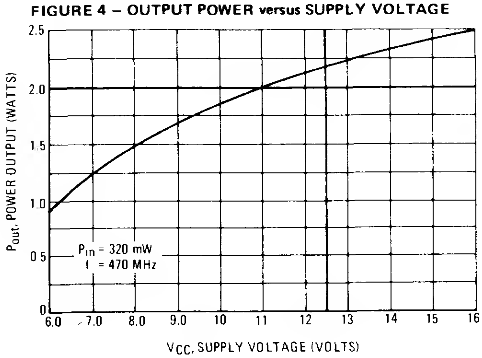
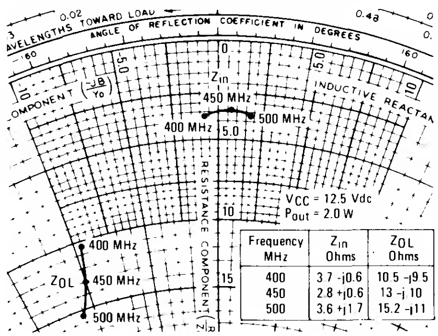


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



Frequency MHz	Zin Ohms	ZOL Ohms
400	3.7 -j0.6	10.5 -j9.5
450	2.8 +j0.6	13 -j 10
500	3.6 +j1.7	15.2 -j11

MRF630

CASE 79-03, STYLE 5

UHF AMPLIFIER TRANSISTOR

NPN SILICON

7

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CES}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.75 50	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

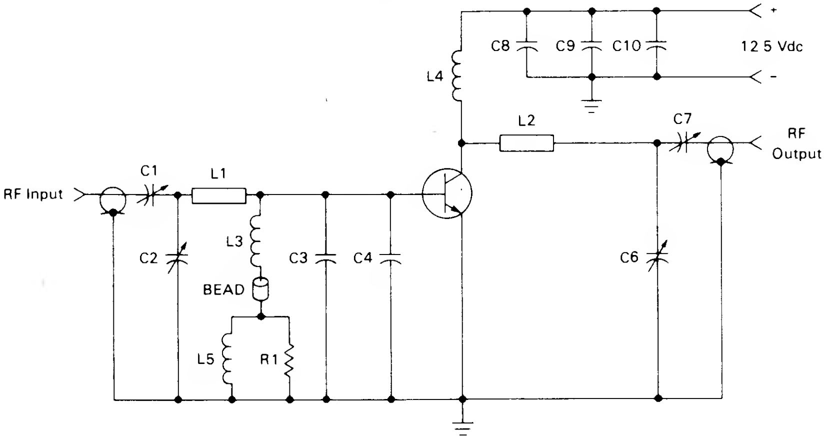
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 12.5 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	60	—	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	12	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 3.0 W, f = 470 MHz)	G_{PE}	9.5	10	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 3.0 W, f = 470 MHz)	η	—	55	—	%

FIGURE 1 — 470 MHz TEST CIRCUIT SCHEMATIC



C1, C7 — 1.5 - 20 pF Johanson
C2, C6 — 1 - 10 pF Johanson
C3, C4 — 27 pF Mini-Unelco
C8 — 250 pF Unelco
C9 — 0.047 μF Erie Disc Cap 10 V
C10 — 1.0 μF Electrolytic

L1, L2 — Copper Strap, 1" Length × 0.225 Width × 0.005" Thickness
L3 — 0.33 μH Molded Choke
L4 — 0.12 μH Molded Choke
L5 — 1.2 μH Molded Choke
R1 — 10 Ω, 1/4 W

FIGURE 2 — OUTPUT POWER versus INPUT POWER

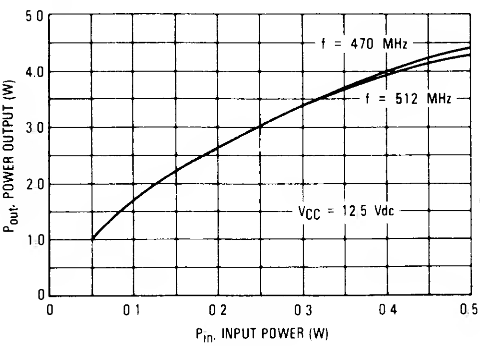


FIGURE 3 — OUTPUT POWER versus FREQUENCY

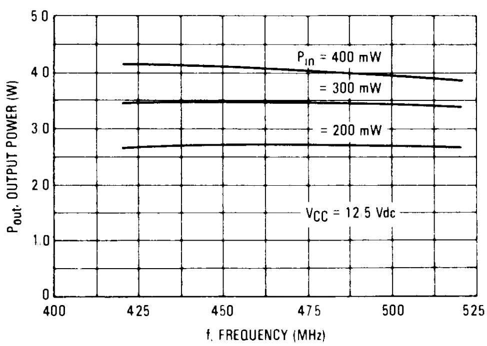


FIGURE 4 — POWER OUT versus SUPPLY VOLTAGE

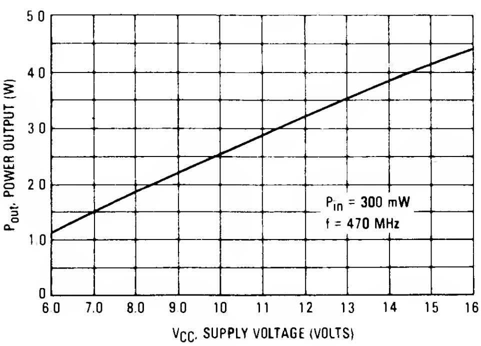
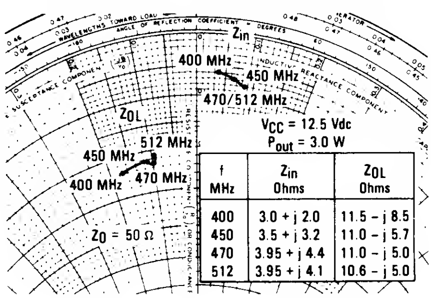


FIGURE 5 — SERIES EQUIVALENT IMPEDANCE



f MHz	Z_{in} Ohms	Z_{OL} Ohms
400	3.0 + j 2.0	11.5 − j 8.5
450	3.5 + j 3.2	11.0 − j 5.7
470	3.95 + j 4.4	11.0 − j 5.0
512	3.95 + j 4.1	10.6 − j 5.0

FIGURE 6 — OUTPUT POWER versus FREQUENCY, BROADBAND CIRCUIT

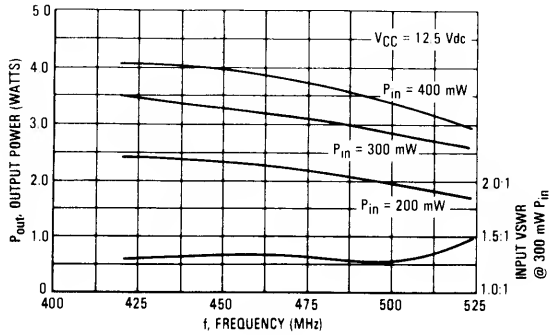
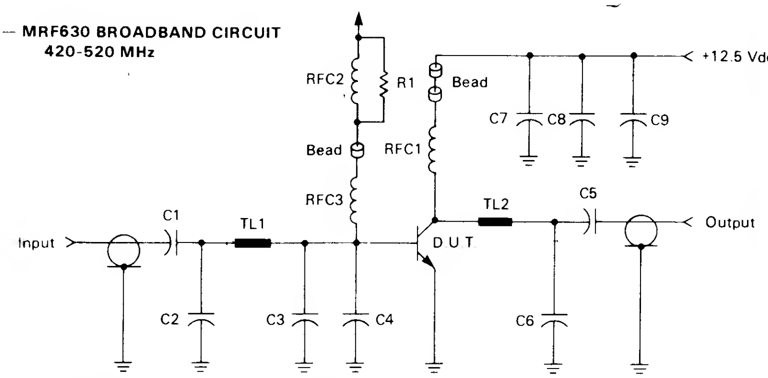
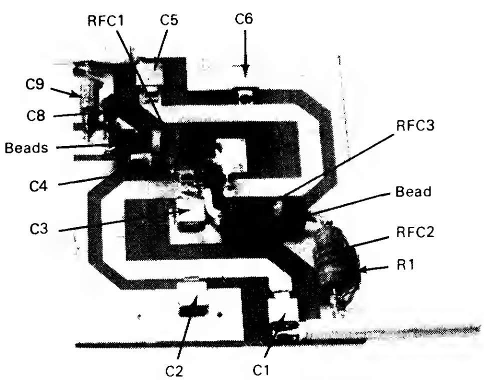


FIGURE 7 — MRF630 BROADBAND CIRCUIT 420-520 MHz



C1, C5 — 43 pF Mini-Unelco
C2 — 10 pF Mini-Unelco
C3 — 18 pF Mini-Unelco
C4 — 27 pF Mini-Unelco
C6 — 6.8 pF Mini-Unelco
C7 — 220 pF Ceramic Chip
C8 — 0.1 mF
C9 — 1.0 mF Tantalum
RFC1 — 0.47 μH Molded Choke
RFC2 — 1.0 μH Molded Choke
RFC3 — 0.3 μH Molded Choke
R1 — 12 Ω/1/4 W
TL1 — Transmission Line 0.166" × 1.85" (WXL)
TL2 — Transmission Line 0.166" × 1.77" (WXL)
Board Material — 2 oz 0.0625" TFG

FIGURE 8 — BROADBAND CIRCUIT



Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.375 3.3	Watt mW/°C
Storage Temperature	T_{stg}	150	°C

MRF901

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	300	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	30	80	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 15 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.4	1.0	pF
Noise Figure (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 GHz)	NF	—	2.0	2.5	dB
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 6.0 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	G_{pe}	10	12	—	dB
Third Order Intercept (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 0.9 GHz)	—	—	+23	—	dBm

FIGURE 1 — 1.0 GHz TEST CIRCUIT SCHEMATIC

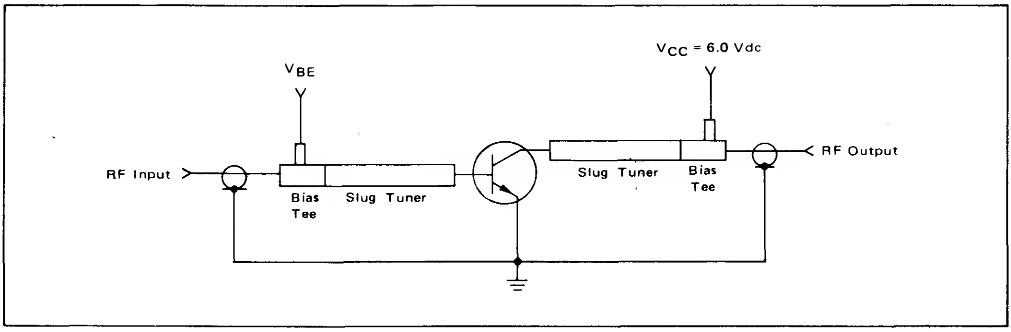


FIGURE 2 — MAXIMUM UNILATERAL GAIN versus FREQUENCY

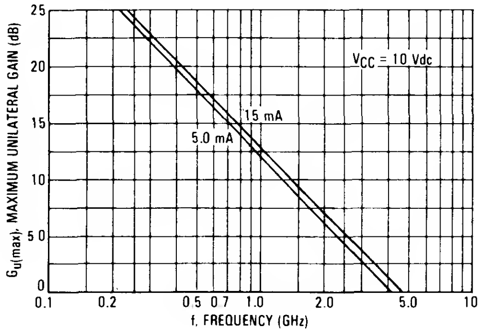


FIGURE 3 — CURRENT-GAIN — BANDWIDTH PRODUCT versus COLLECTOR CURRENT

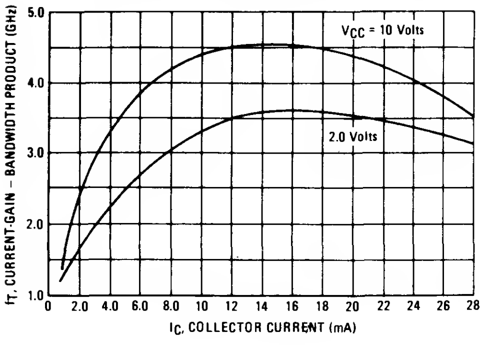


FIGURE 4 — NOISE FIGURE versus FREQUENCY

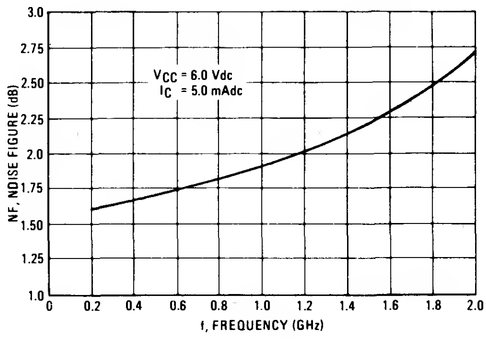


FIGURE 5 – NOISE FIGURE versus COLLECTOR CURRENT

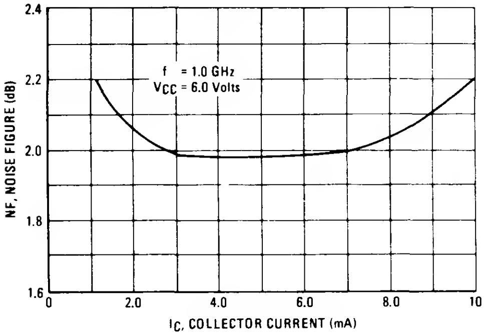


FIGURE 6 – OUTPUT POWER versus INPUT POWER

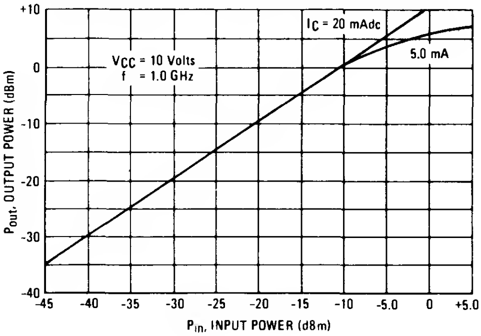


FIGURE 7 – G_{max} versus FREQUENCY

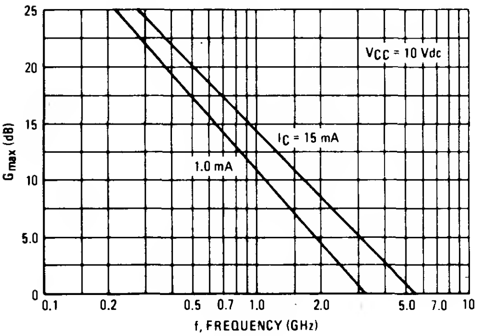


FIGURE 8 – COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

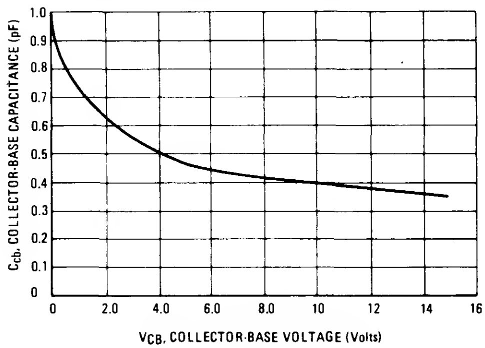


TABLE I – S_{11}

FREQUENCY (MHz)		200		500		1000		1500		2000	
V_{CC}	I_C	$\lvert S_{11}\rvert$	∠φ	$\lvert S_{11}\rvert$	∠φ	$\lvert S_{11}\rvert$	∠φ	$\lvert S_{11}\rvert$	∠φ	$\lvert S_{11}\rvert$	∠φ
1 Volt	1.0mA	.83	-54	.65	-110	.61	-153	.62	+177	.65	+157
	2.5	.72	-74	.57	-132	.56	-171	.58	+165	.61	+148
	5.0	.63	-98	.55	-151	.55	+174	.58	+154	.60	+140
	10	.55	-130	.55	-170	.56	+164	.59	+148	.61	+135
	15	.55	-147	.56	-178	.58	+160	.62	+145	.63	+133
	20	.58	-165	.60	+174	.62	+158	.65	+144	.67	+132
3 Volts	1.0	.85	-48	.68	-100	.61	-149	.62	+178	.65	+156
	2.5	.75	-63	.58	-121	.53	-169	.56	+164	.59	+146
	5.0	.64	-82	.52	-139	.51	+177	.54	+156	.57	+139
	10	.53	-112	.48	-160	.51	+167	.54	+149	.56	+134
	15	.49	-126	.48	-168	.52	+162	.55	+145	.57	+132
	20	.48	-137	.49	-173	.53	+160	.56	+145	.58	+131
6 Volts	1.0	.87	-45	.71	-94	.60	-148	.60	+179	.63	+156
	2.5	.77	-58	.60	-114	.52	-164	.55	+168	.57	+148
	5.0	.66	-75	.52	-132	.48	-177	.52	+159	.54	+142
	10	.53	-101	.46	-151	.47	+171	.50	+152	.53	+137
	15	.47	-115	.45	-162	.47	+166	.51	+148	.53	+135
	20	.46	-125	.45	-167	.48	+163	.52	+147	.54	+134
10 Volts	1.0	.88	-43	.72	-91	.60	-145	.60	-178	.63	+158
	2.5	.79	-55	.60	-109	.52	-160	.54	+170	.57	+150
	5.0	.68	-70	.50	-130	.47	-175	.50	+160	.53	+143
	10	.55	-93	.45	-147	.45	+173	.48	+154	.52	+138
	15	.50	-107	.43	-158	.44	+168	.49	+151	.52	+136
	20	.47	-116	.43	-163	.45	+166	.49	+150	.52	+136

7

TABLE II – S_{21}

FREQUENCY (MHz)		200		500		1000		1500		2000	
V_{CC}	I_C	$\|S_{21}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$
1 Volt	1.0mA	4.2	+140	2.7	+104	1.4	+73	.96	+52	.77	+39
	2.5	7.2	+130	3.9	+98	2.1	+73	1.4	+55	1.1	+42
	5.0	9.9	+121	4.8	+92	2.6	+72	1.8	+57	1.4	+44
	10	12.0	+109	5.2	+87	2.8	+70	1.9	+57	1.5	+44
	15	11.4	+103	4.9	+84	2.7	+68	1.8	+55	1.4	+42
	20	6.3	+96	2.6	+81	1.9	+65	1.3	+52	1.0	+41
3 Volts	1.0	4.5	+144	3.0	+110	1.5	+78	1.0	+56	.82	+43
	2.5	7.8	+136	4.5	+103	2.5	+76	1.7	+58	1.3	+45
	5.0	11.2	+127	5.7	+97	3.0	+74	2.0	+58	1.6	+45
	10	14.9	+116	6.8	+91	3.4	+72	2.3	+58	1.8	+45
	15	16	+111	7.0	+88	3.6	+70	2.4	+57	1.8	+45
	20	16.4	+108	7.0	+87	3.5	+69	2.4	+56	1.8	+44
6 Volts	1.0	4.5	+146	3.1	+113	1.8	+81	1.2	+60	.96	+46
	2.5	7.8	+139	4.8	+106	2.7	+78	1.8	+60	1.4	+46
	5.0	11.6	+130	6.2	+99	3.3	+75	2.2	+60	1.7	+47
	10	15.9	+120	7.5	+92	3.8	+73	2.5	+59	1.9	+47
	15	17.2	+114	7.7	+90	4.0	+71	2.6	+58	2.0	+46
	20	17.7	+110	7.8	+88	4.0	+70	2.6	+57	2.0	+45
10 Volts	1.0	4.5	+147	3.2	+114	1.8	+82	1.2	+61	.96	+47
	2.5	7.8	+140	4.9	+107	2.7	+79	1.8	+61	1.4	+47
	5.0	11.7	+132	6.4	+100	3.5	+75	2.3	+60	1.8	+48
	10	15.9	+121	7.6	+93	4.0	+73	2.6	+58	2.0	+47
	15	17.4	+115	8.0	+90	4.0	+71	2.7	+57	2.0	+46
	20	17.8	+112	8.0	+88	4,0	+70	2.6	+56	2.0	+45

TABLE III – S_{12}

FREQUENCY (MHz)		200		500		1000		1500		2000	
V_{CC}	I_C	$\|S_{12}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$
1 Volt	1.0mA	.09	+57	.14	+32	.15	+17	.15	+13	.13	+21
	2.5	.08	+49	.10	+32	.12	+27	.13	+32	.14	+40
	5.0	.06	+43	.08	+35	.10	+42	.13	+48	.16	+51
	10	.05	+42	.06	+45	.09	+54	.13	+57	.17	+57
	15	.04	+43	.06	+50	.09	+60	.13	+60	.18	+60
	20	.03	+41	.05	+55	.09	+63	.14	+64	.18	+62
3 Volts	1.0	.06	+61	.10	+37	.13	+21	.12	+20	.10	+31
	2.5	.06	+57	.08	+36	.09	+33	.10	+40	.12	+49
	5.0	.05	+51	.07	+39	.08	+45	.11	+52	.14	+56
	10	.04	+49	.05	+49	.08	+56	.11	+61	.15	+61
	15	.03	+49	.05	+55	.08	+62	.12	+64	.15	+64
	20	.03	+52	.04	+59	.08	+65	.12	+65	.15	+65
6 Volts	1.0	.05	+63	.09	+40	.10	+26	.09	+29	.09	+43
	2.5	.05	+59	.07	+39	.08	+37	.09	+45	.11	+55
	5.0	.04	+55	.05	+42	.07	+48	.09	+56	.12	+62
	10	.03	+50	.04	+51	.07	+58	.10	+64	.13	+66
	15	.02	+53	.04	+55	.07	+64	.10	+67	.13	+68
	20	.03	+54	.04	+60	.07	+66	.10	+69	.13	+69
10 Volts	1.0	.05	+65	.08	+41	.09	+28	.08	+32	.08	+48
	2.5	.04	+59	.06	+42	.07	+38	.08	+48	.09	+59
	5.0	.03	+57	.05	+44	.07	+51	.08	+60	.11	+65
	10	.03	+54	.04	+51	.06	+60	.09	+66	.12	+69
	15	.03	+52	.04	+55	.06	+64	.09	+68	.12	+70
	20	.02	+54	.03	+59	.06	+66	.09	+69	.12	+71

TABLE IV – S_{22}

FREQUENCY (MHz)		200		500		1000		1500		2000	
V_{CC}	I_C	$\lvert S_{22} \rvert$	$\angle\phi$	$\lvert S_{22} \rvert$	$\angle\phi$	$\lvert S_{22} \rvert$	$\angle\phi$	$\lvert S_{22} \rvert$	$\angle\phi$	$\lvert S_{22} \rvert$	$\angle\phi$
1 Volt	1.0mA	.88	-23	.66	-41	.57	-56	.54	-76	.53	-96
	2.5	.76	-34	.48	-50	.40	-61	.37	-78	.37	-98
	5.0	.61	-45	.34	-58	.25	-67	.23	-84	.24	-103
	10	.42	-60	.20	-70	.15	-75	.14	-95	.16	-115
	15	.31	-67	.15	-77	.11	-83	.11	-105	.14	-125
	20	.16	-72	.09	-82	.10	-92	.12	-119	.16	-140
3 Volts	1.0	.91	-18	.75	-32	.66	-47	.62	-65	.60	-82
	2.5	.83	-25	.60	-38	.47	-50	.44	-64	.43	-81
	5.0	.72	-32	.47	-41	.36	-50	.34	-64	.33	-80
	10	.56	-40	.34	-42	.27	-49	.25	-62	.25	-78
	15	.48	-43	.30	-41	.23	-46	.21	-60	.22	-76
	20	.43	-43	.27	-39	.22	-44	.21	-58	.22	-75
6 Volts	1.0	.93	-15	.79	-27	.68	-42	.65	-57	.63	-74
	2.5	.87	-20	.67	-31	.55	-42	.52	-56	.51	-71
	5.0	.77	-26	.55	-34	.45	-41	.43	-53	.42	-68
	10	.63	-32	.43	-33	.37	-38	.36	-50	.35	-64
	15	.57	-33	.40	-31	.35	-35	.34	-47	.33	-62
	20	.53	-33	.38	-29	.34	-34	.33	-46	.33	-61
10 Volts	1.0	.94	-13	.82	-25	.73	-38	.69	-53	.67	-69
	2.5	.89	-18	.70	-28	.60	-38	.57	-51	.56	-66
	5.0	.81	-23	.60	-29	.50	-37	.48	-48	.47	-61
	10	.68	-27	.50	-28	.44	-34	.43	-45	.42	-58
	15	.62	-28	.47	-26	.43	-30	.42	-42	.42	-56
	20	.59	-27	.46	-24	.43	-30	.42	-42	.42	-56

MRF904

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.2 1.14	Watt mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 15 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	f_T	—	4.0	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	1.0	pF
Noise Figure (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz) (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 GHz)	NF	 — —	 1.5 2.5	 — —	dB
FUNCTIONAL TEST					
Maximum Available Power(1) (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz) (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 GHz)	G_{max}	 — —	 16 10	 — —	dB

(1) $G_{max} = \dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

FIGURE 1 – NOISE FIGURE versus FREQUENCY

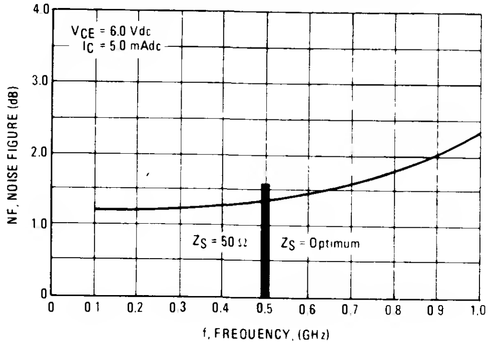


FIGURE 2 – NOISE FIGURE versus COLLECTOR CURRENT

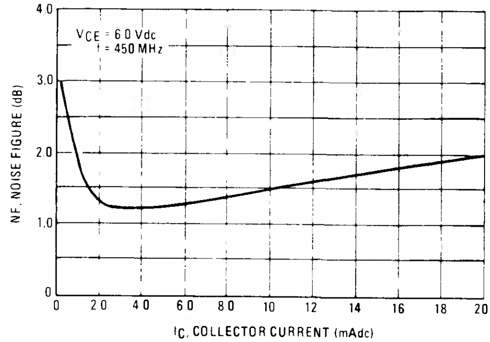


FIGURE 3 – COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

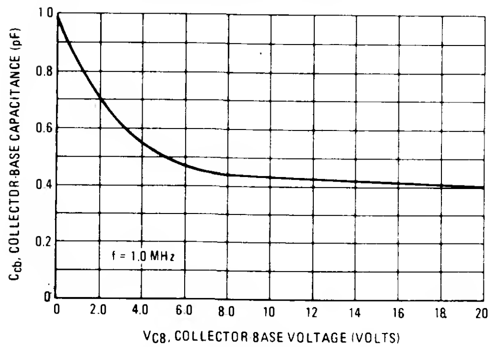


FIGURE 4 – UNILATERALIZED GAIN (G_{max}) versus FREQUENCY

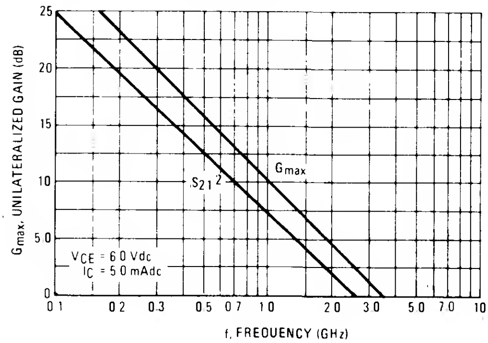


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT versus COLLECTOR CURRENT

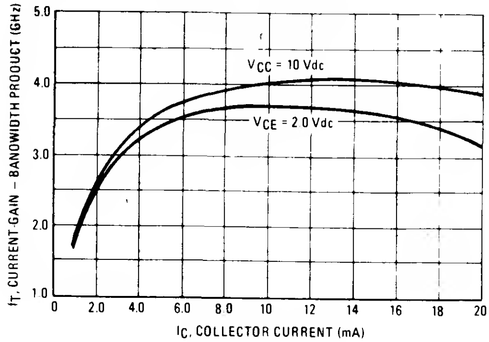
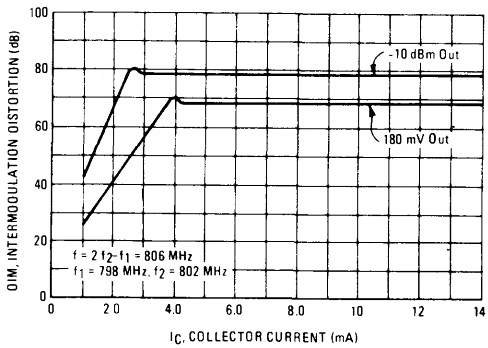


FIGURE 6 – INTERMODULATION DISTORTION versus COLLECTOR CURRENT



7

TABLE 1 – S_{11} PARAMETERS

Frequency (MHz)		100		200		500		800		1000	
V_{CC} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
1.0	1.0	0.941	-22	0.85	-43	0.57	-91	0.37	-128	0.30	-151
	2.5	0.85	-31	0.67	-57	0.35	-102	0.20	-136	0.14	-157
	5.0	0.69	-44	0.46	-71	0.21	-109	0.10	-144	0.069	-166
	10	0.45	-67	0.28	-94	0.13	-136	0.087	172	0.075	145
	15	0.37	-110	0.31	-145	0.26	170	0.27	139	0.27	122
	30	0.71	-178	0.71	169	0.68	144	0.68	121	0.65	107
3.0	1.0	0.94	-19	0.87	-37	0.61	-80	0.39	-114	0.30	-134
	2.5	0.87	-26	0.71	-47	0.39	-84	0.21	-106	0.15	-115
	5.0	0.74	-34	0.52	-55	0.25	-77	0.13	-82	0.109	-79
	10	0.55	-42	0.35	-58	0.18	-66	0.11	-60	0.105	-55
	15	0.46	-46	0.28	-59	0.15	-64	0.096	-55	0.092	-49
	30	0.28	-95	0.21	-134	0.16	175	0.17	135	0.17	116
6.0	1.0	0.95	-18	0.88	-35	0.63	-76	0.40	-108	0.30	-126
	2.5	0.89	-23	0.74	-43	0.42	-77	0.23	-94	0.17	-100
	5.0	0.77	-31	0.56	-49	0.29	-67	0.18	-69	0.15	-66
	10	0.61	-37	0.40	-50	0.23	-55	0.16	-51	0.16	-50
	15	0.52	-40	0.34	-51	0.20	-52	0.15	-47	0.15	-47
	30	0.36	-55	0.21	-70	0.098	-77	0.037	-59	0.033	-27
10	1.0	0.96	-17	0.89	-33	0.65	-73	0.41	-103	0.31	-121
	2.5	0.89	-22	0.76	-41	0.44	-73	0.25	-88	0.18	-93
	5.0	0.79	-28	0.59	-46	0.32	-63	0.20	-65	0.18	-63
	10	0.64	-34	0.44	-47	0.26	-52	0.19	-49	0.18	-49
	15	0.57	-37	0.38	-48	0.23	-49	0.18	-46	0.17	-46
	30	0.41	-51	0.24	-64	0.12	-67	0.061	-52	0.055	-36

TABLE 2 – S_{21} PARAMETERS

Frequency (MHz)		100		200		500		800		1000	
V_{CC} (Volts)	I_C (mA)	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
1.0	1.0	5.32	156	3.06	137	2.22	97	1.65	70	1.44	56
	2.5	6.79	146	5.57	124	3.15	86	2.14	64	1.81	52
	5.0	10.97	133	7.60	110	3.62	79	2.38	61	2.00	49
	10	13.16	118	8.07	99	3.60	74	2.35	57	1.96	46
	15	9.84	108	5.66	91	2.44	67	1.63	49	1.38	38
	30	1.65	83	0.88	69	0.47	46	0.43	37	0.45	31
3.0	1.0	3.33	159	3.11	142	2.36	103	1.79	76	1.55	62
	2.5	6.89	150	5.85	129	3.48	92	2.38	70	2.00	58
	5.0	11.49	138	8.34	115	4.12	84	2.70	66	2.25	55
	10	15.71	125	9.82	104	4.39	79	2.85	63	2.34	53
	15	16.97	119	10.05	100	4.39	77	2.83	61	2.34	52
	30	12.66	108	7.02	92	2.98	70	1.94	54	1.61	44
6.0	1.0	3.31	160	3.10	144	2.41	106	1.83	79	1.60	65
	2.5	6.80	151	5.85	131	3.60	94	2.46	77	2.07	60
	5.0	11.44	140	8.54	117	4.28	86	2.83	68	2.33	57
	10	15.85	127	10.14	107	4.61	81	2.96	65	2.46	55
	15	17.20	122	10.47	102	4.60	79	2.96	63	2.45	54
	30	16.37	113	9.38	96	4.00	75	2.58	59	2.14	49
10	1.0	3.25	160	3.08	145	2.40	108	1.83	81	1.61	67
	2.5	6.73	152	5.85	132	3.63	96	2.50	74	2.10	62
	5.0	11.19	142	8.49	119	4.34	88	2.85	69	2.37	59
	10	15.59	129	10.16	108	4.66	82	3.00	66	2.47	56
	15	17.04	124	10.49	104	4.65	80	2.99	64	2.47	55
	30	16.18	115	9.38	98	4.03	96	2.60	60	2.14	50

TABLE 3 – S_{12} PARAMETERS

Frequency (MHz)		100		200		500		800		1000	
V_{CC} (Volts)	I_C (mA)	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ
1.0	1.0	0.054	73	0.097	61	0.159	41	0.184	36	0.194	37
	2.5	0.051	69	0.084	58	0.140	50	0.189	48	0.220	46
	5.0	0.046	65	0.072	60	0.137	58	0.201	53	0.239	50
	10	0.041	64	0.067	64	0.142	62	0.215	56	0.256	51
	15	0.043	61	0.070	63	0.152	62	0.230	55	0.277	50
	30	0.058	50	0.093	58	0.209	57	0.311	46	0.372	39
3.0	1.0	0.039	75	0.072	65	0.123	46	0.143	42	0.151	44
	2.5	0.037	72	0.063	62	0.110	54	0.150	53	0.174	52
	5.0	0.033	70	0.055	64	0.108	62	0.160	58	0.190	55
	10	0.030	70	0.050	68	0.109	67	0.165	61	0.199	57
	15	0.028	70	0.049	70	0.109	68	0.167	62	0.200	57
	30	0.026	68	0.046	70	0.105	69	0.165	64	0.200	61
6.0	1.0	0.032	76	0.060	66	0.106	49	0.123	45	0.131	48
	2.5	0.031	73	0.054	64	0.095	57	0.130	56	0.151	55
	5.0	0.028	71	0.048	66	0.094	64	0.139	61	0.165	58
	10	0.026	71	0.043	69	0.094	68	0.144	63	0.172	59
	15	0.024	71	0.042	71	0.093	69	0.144	64	0.172	60
	30	0.021	71	0.037	72	0.086	71	0.134	67	0.162	63
10	1.0	0.028	77	0.053	68	0.095	50	0.109	47	0.116	50
	2.5	0.027	74	0.048	65	0.085	58	0.116	57	0.134	57
	5.0	0.025	73	0.043	67	0.084	64	0.125	62	0.148	60
	10	0.023	72	0.037	69	0.084	69	0.128	64	0.153	61
	15	0.022	73	0.037	70	0.084	69	0.128	65	0.152	62
	30	0.019	72	0.033	72	0.076	72	0.119	68	0.143	66

TABLE 4 – S_{22} PARAMETERS

Frequency (MHz)		100		200		500		800		1000	
V_{CC} (Volts)	I_C (mA)	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ
1.0	1.0	0.966	-12	0.893	-23	0.693	-41	0.612	-53	0.594	-59
	2.5	0.901	-18	0.760	-29	0.548	-42	0.498	-51	0.494	-56
	5.0	0.793	-24	0.619	-32	0.456	-39	0.429	-49	0.439	-54
	10	0.635	-29	0.486	-32	0.390	-36	0.377	-47	0.389	-53
	15	0.453	-29	0.364	-29	0.313	-34	0.309	-48	0.321	-14
	30	0.048	-78	0.035	-88	0.032	-135	0.031	-162	0.007	-167
3.0	1.0	0.976	-9.0	0.926	-18	0.770	-35	0.702	-46	0.683	-51
	2.5	0.935	-13	0.828	-23	0.648	-35	0.608	-43	0.608	-48
	5.0	0.853	-18	0.712	-25	0.577	-32	0.555	-41	0.565	-46
	10	0.758	-20	0.629	-23	0.539	-29	0.529	-39	0.544	-44
	15	0.711	-20	0.601	-22	0.533	-27	0.526	-38	0.540	-44
	30	0.631	-15	0.576	-16	0.548	-25	0.546	-38	0.558	-45
6.0	1.0	0.982	-8.0	0.939	-16	0.803	-31	0.742	42	0.734	-47
	2.5	0.947	-11	0.861	-20	0.699	-31	0.662	-40	0.660	-45
	5.0	0.882	-15	0.759	-21	0.633	-29	0.617	-31	0.627	-43
	10	0.801	-17	0.684	-20	0.607	-26	0.601	-35	0.610	-41
	15	0.769	-17	0.667	-19	0.602	-25	0.601	-35	0.607	-40
	30	0.737	-14	0.672	-15	0.640	-22	0.641	-33	0.655	-40
10	1.0	0.983	-7.0	0.949	-14	0.830	-29	0.774	-39	0.765	-40
	2.5	0.954	-10	0.880	-18	0.733	-29	0.698	-37	0.702	-42
	5.0	0.901	-13	0.793	-19	0.676	-27	0.659	-35	0.668	-41
	10	0.834	-15	0.725	-18	0.646	-24	0.646	-33	0.658	-39
	15	0.802	-15	0.706	-17	0.645	-23	0.648	-33	0.661	-39
	30	0.776	-13	0.712	-14	0.678	-22	0.686	-32	0.699	-38

MRF905

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

RF OSCILLATOR TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	2.5 40	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

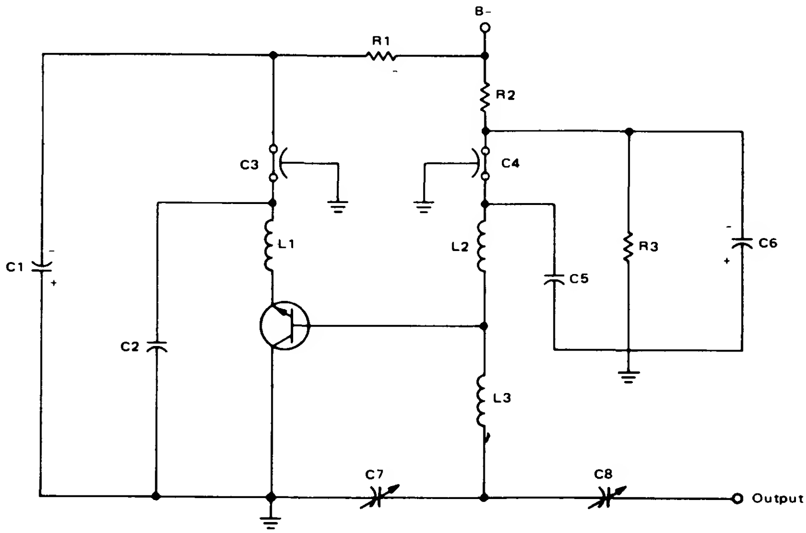
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	60	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)	f_T	—	2500	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	5.0	pF
FUNCTIONAL TEST					
Common-Collector Oscillator Output Power (Figure 1) (V_E = −20 Vdc, $I_E \cong$ 110 mAdc, f $\cong$ 1.68 GHz)	P_{out}	400	500	—	mW

FIGURE 1 – 1.68 GHz OSCILLATOR TEST CIRCUIT SCHEMATIC



C1,C6	1.0 μF, 35 Vdc TANTALUM	R1	47 Ohms, 1/4 Watt
C2,C5	0.1 μF Ceramic Disk	R2	510 Ohms, 1/4 Watt
C3,C4	680 pF Feedthru	R3	1.5 kΩ, 1/4 Watt
C7,C8	0.4-6.0 pF JOHANSON	L1,L2	5 Turns, #22 AWG, 0.125" I.D.
		L3	#20 AWG, 0.4" Length.

MRF911

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Peak	I_C	40	mAdc
Total Device Dissipation @ $T_L = 50°C$ Derate above 50°C	P_D	400 4.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Lead	$R_{\theta JL}$	250	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	f_T	—	5.0	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.6	1.0	pF
FUNCTIONAL TEST					
Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 2.0 GHz)	NF	 — —	 2.5 4.0	 — —	dB
Power Gain at Optimum Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 2.0 GHz)	G_{NF}	 — —	 10 6.0	 — —	dB
Maximum Available Power Gain(1) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 2.0 GHz)	G_{max}	 — —	 12.5 7.5	 — —	dB

(1) $G_{max} = \dfrac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 — POWER DERATING

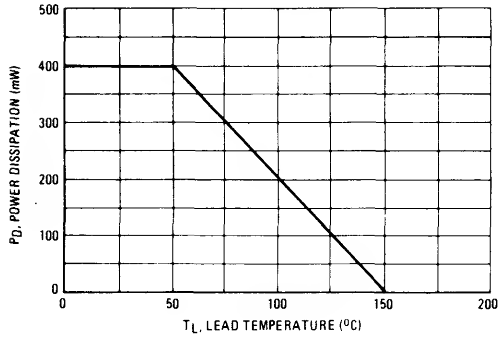


FIGURE 2 — POWER GAIN AND NOISE FIGURE versus FREQUENCY

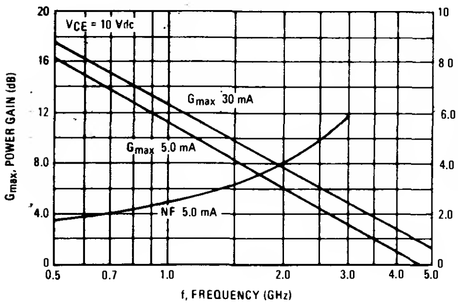


FIGURE 3 — POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

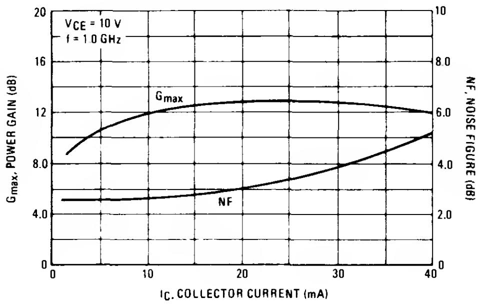


FIGURE 4 — S_{11} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
5.0	2.0	0.66	-125	0.64	-175	0.68	160	0.73	140
	5.0	0.57	-150	0.58	170	0.62	150	0.66	135
	10	0.54	-165	0.57	160	0.60	145	0.64	130
	20	0.54	-180	0.57	155	0.60	140	0.64	125
	30	0.54	175	0.57	155	0.61	140	0.65	125
10	2.0	0.66	-120	0.63	-170	0.67	160	0.71	140
	5.0	0.56	-145	0.56	175	0.60	150	0.64	135
	10	0.51	-160	0.53	165	0.57	145	0.61	130
	20	0.49	-175	0.52	160	0.57	145	0.60	130
	30	0.49	-175	0.53	160	0.57	145	0.61	130

FIGURE 5 – S_{22} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ
5.0	2.0	0.61	-45	0.50	-60	0.48	-80	0.50	-100
	5.0	0.40	-55	0.31	-65	0.30	-85	0.32	-100
	10	0.27	-60	0.20	-70	0.20	-90	0.23	-105
	20	0.19	-70	0.13	-75	0.14	-95	0.17	-110
	30	0.16	-70	0.11	-75	0.13	-95	0.16	-110
10	2.0	0.66	-35	0.55	-50	0.53	-70	0.54	-90
	5.0	0.47	-45	0.38	-50	0.37	-70	0.38	-75
	10	0.35	-45	0.28	-50	0.27	-65	0.29	-85
	20	0.26	-45	0.22	-50	0.22	-65	0.24	-80
	30	0.25	-40	0.21	-45	0.22	-60	0.24	-80

FIGURE 6 – S_{21} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
5.0	2.0	3.24	100	1.84	70	1.23	50	0.96	35
	5.0	4.85	90	2.60	70	1.76	50	1.38	40
	10	5.78	85	3.04	70	2.05	50	1.61	40
	20	6.40	85	3.30	65	2.23	50	1.24	40
	30	6.47	80	3.35	65	2.26	50	1.76	40
10	2.0	3.42	100	1.95	70	1.31	50	1.01	35
	5.0	5.20	95	2.80	70	1.89	50	1.45	40
	10	6.22	90	3.28	70	2.20	55	1.71	40
	20	6.82	85	3.55	65	2.37	55	1.84	40
	30	6.90	85	3.55	65	2.36	50	1.81	40

FIGURE 7 – S_{12} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ
5.0	2.0	0.11	30	0.12	25	0.11	35	0.13	50
	5.0	0.08	40	0.10	45	0.13	55	0.17	55
	10	0.07	50	0.10	55	0.14	60	0.19	60
	20	0.06	60	0.11	65	0.15	65	0.20	60
	30	0.06	65	0.11	65	0.15	65	0.20	60
10	2.0	0.10	35	0.10	30	0.10	40	0.12	55
	5.0	0.07	40	0.09	45	0.12	55	0.15	60
	10	0.06	50	0.09	55	0.13	60	0.17	60
	20	0.06	60	0.10	65	0.13	65	0.18	60
	30	0.06	60	0.10	65	0.14	65	0.18	65

7

MRF912

CASE 303-01, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Peak	I_C	50	mAdc
Total Device Dissipation @ $T_C = 75°C$ Derate above 75°C	P_D	500 4.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	f_T	—	5.0	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.6	1.0	pF
FUNCTIONAL TEST					
Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 2.0 GHz)	NF	 — —	 2.5 4.0	 3.0 —	dB
Power Gain at Optimum Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 2.0 GHz)	G_{NF}	 — —	 12 7.0	 — —	dB
Maximum Available Power Gain(1) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 2.0 GHz)	G_{max}	 14 —	 16.5 11.0	 — —	dB

(1) $G_{max} = \dfrac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

7

FIGURE 1 – POWER DERATING

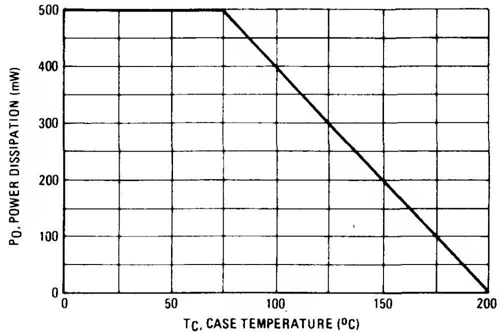


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

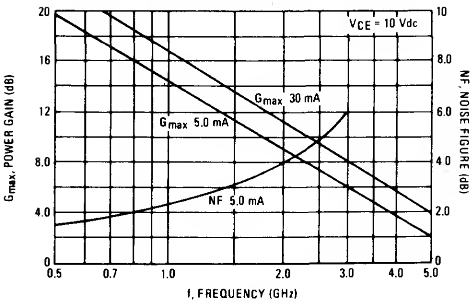


FIGURE 3 – POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

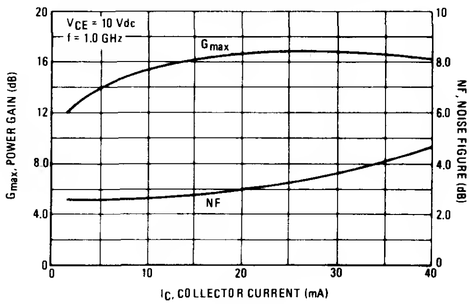


FIGURE 4 – S_{11} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
5.0	2.0	0.76	-120	0.74	-160	0.76	-175	0.79	175
	5.0	0.72	-145	0.73	-170	0.75	175	0.77	165
	10	0.71	-160	0.74	180	0.75	170	0.77	160
	20	0.73	-170	0.75	175	0.77	165	0.79	155
	30	0.74	-175	0.76	170	0.78	165	0.81	155
	40	0.74	-180	0.76	165	0.79	155	0.81	145
	50	0.74	180	0.77	165	0.79	155	0.82	145
10	2.0	0.77	-115	0.74	-155	0.76	-170	0.78	175
	5.0	0.71	-140	0.72	-170	0.73	175	0.75	165
	10	0.69	-155	0.71	-175	0.73	170	0.75	165
	20	0.69	-165	0.72	175	0.74	165	0.76	160
	30	0.70	-170	0.73	175	0.75	165	0.77	160
	40	0.69	-175	0.72	165	0.75	155	0.78	145
	50	0.70	-175	0.73	165	0.76	155	0.80	145

FIGURE 5 – S_{22} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ
5.0	2.0	0.66	-50	0.57	-70	0.57	-95	0.61	-115
	5.0	0.45	-65	0.37	-85	0.39	-105	0.44	-120
	10	0.33	-80	0.27	-100	0.30	-115	0.35	-130
	20	0.24	-95	0.21	-115	0.24	-125	0.29	-135
	30	0.21	-100	0.18	-120	0.22	-125	0.28	-135
	40	0.18	-100	0.16	-115	0.20	-125	0.27	-135
	50	0.17	-95	0.16	-110	0.21	-120	0.28	-135
10	2.0	0.71	-45	0.62	-65	0.62	-85	0.64	-105
	5.0	0.51	-55	0.43	-70	0.44	-90	0.48	-105
	10	0.37	-60	0.31	-75	0.33	-95	0.38	-110
	20	0.27	-70	0.23	-80	0.26	-95	0.32	-115
	30	0.23	-65	0.21	-80	0.25	-95	0.31	-110
	40	0.23	-60	0.22	-70	0.25	-90	0.32	-110
	50	0.24	-50	0.24	-65	0.28	-90	0.34	-105

FIGURE 6 – S_{21} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
5.0	2.0	3.52	102	1.97	70	1.33	50	0.99	35
	5.0	5.61	95	2.96	70	1.98	50	1.50	35
	10	6.84	90	3.55	70	2.35	55	1.78	40
	20	7.65	85	3.94	65	2.59	50	1.96	40
	30	7.93	85	4.02	65	2.63	50	1.98	40
	40	7.87	80	3.95	65	2.57	45	1.92	30
	50	7.65	80	3.86	60	2.48	45	1.86	30
10	2.0	3.70	105	2.12	75	1.43	50	1.07	35
	5.0	6.09	95	3.24	70	2.17	50	1.62	35
	10	7.53	90	3.91	70	2.58	55	1.96	40
	20	8.54	85	4.38	70	2.86	55	2.17	40
	30	8.79	85	4.45	65	2.92	50	2.17	40
	40	8.58	80	4.32	65	2.80	45	2.08	30
	50	8.30	80	4.15	60	2.69	45	1.98	30

FIGURE 7 – S_{12} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ
5.0	2.0	0.11	25	0.11	5.0	0.10	-5	0.09	-5
	5.0	0.07	25	0.08	15	0.08	15	0.08	15
	10	0.05	25	0.06	25	0.07	30	0.08	30
	20	0.04	35	0.05	40	0.07	40	0.08	40
	30	0.03	45	0.05	45	0.06	50	0.08	45
	40	0.03	50	0.05	50	0.07	50	0.08	50
	50	0.03	55	0.05	55	0.06	50	0.08	50
10	2.0	0.09	25	0.10	5.0	0.09	0	0.08	0
	5.0	0.06	25	0.07	15	0.07	20	0.07	20
	10	0.05	30	0.06	30	0.06	30	0.07	35
	20	0.03	40	0.05	40	0.06	45	0.07	40
	30	0.03	40	0.05	45	0.06	47	0.07	45
	40	0.03	45	0.05	50	0.06	50	0.07	45
	50	0.03	50	0.04	50	0.06	50	0.07	50

MRF914

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Peak	I_C	40	mAdc
Total Device Dissipation @ $T_A = 75°C$ Derate above 75°C	P_D	200 1.6	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	625	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.7	1.0	pF
FUNCTIONAL TEST					
Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	NF	 — —	 2.0 2.5	 — —	dB
Power Gain at Optimum Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	G_{NF}	 — —	 12 7.0	 — —	dB
Maximum Available Power Gain(1) ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	G_{max}	 — —	 15 10	 — —	dB

(1) $G_{max} = \dfrac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 — POWER DERATING

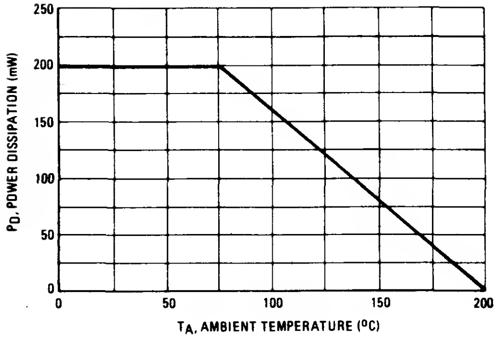


FIGURE 2 — POWER GAIN AND NOISE FIGURE versus FREQUENCY

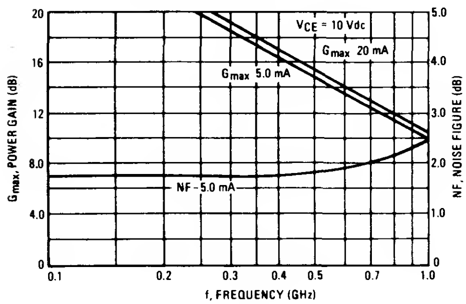


FIGURE 3 — POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

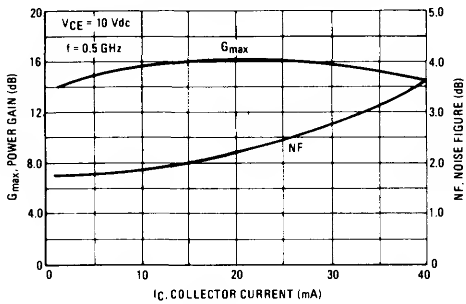


FIGURE 4 — S_{11} PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
V_{CE} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
5.0	2.0	0.84	-35	0.57	-80	0.42	-115	0.34	-140	0.27	-166
	5.0	0.65	-45	0.34	-85	0.23	-115	0.18	-130	0.16	-150
	10	0.48	-50	0.32	-85	0.14	-105	0.12	-115	0.09	-120
	20	0.33	-50	0.15	-75	0.10	-90	0.09	-100	0.09	-101
	30	0.27	-50	0.13	-70	0.09	-85	0.09	-100	0.09	-101
10	2.0	0.86	-30	0.59	-75	0.42	-105	0.34	-130	0.25	-155
	5.0	0.70	-40	0.37	-75	0.24	-95	0.18	-110	0.13	-125
	10	0.55	-45	0.26	-70	0.17	-80	0.14	-90	0.13	-90
	20	0.41	-45	0.21	-60	0.15	-65	0.13	-75	0.14	-80
	30	0.36	-45	0.19	-55	0.14	-65	0.13	-75	0.13	-80

7

FIGURE 5 – S_{22} PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
V_{CE} (Volts)	I_C (mA)	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ
5.0	2.0	0.94	-15	0.77	-25	0.68	-30	0.66	-35	0.64	-45
	5.0	0.85	-20	0.63	-30	0.57	-30	0.55	-35	0.55	-45
	10	0.75	-25	0.55	-25	0.51	-30	0.50	-35	0.50	-40
	20	0.66	-25	0.50	-25	0.47	-30	0.47	-35	0.48	-40
	30	0.62	-25	0.49	-25	0.46	-25	0.46	-30	0.47	-40
10	2.0	0.95	-10	0.81	-20	0.74	-30	0.72	-35	0.71	-40
	5.0	0.87	-15	0.69	-25	0.64	-25	0.63	-30	0.63	-40
	10	0.80	-20	0.63	-20	0.59	-25	0.59	-30	0.60	-40
	20	0.72	-20	0.59	-20	0.57	-23	0.57	-30	0.58	-35
	30	0.70	-20	0.59	-20	0.57	-20	0.57	-30	0.58	-35

FIGURE 6 – S_{21} PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
V_{CE} (Volts)	I_C mA	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
5.0	2.0	5.99	150	4.06	110	2.90	90	2.27	75	1.71	55
	5.0	11.38	135	5.91	100	3.90	80	2.93	70	2.17	55
	10	15.21	125	6.78	95	4.34	80	3.23	70	2.38	55
	20	17.98	115	7.27	90	4.58	75	3.40	65	2.50	50
	30	18.78	110	7.37	85	4.64	75	3.42	65	2.50	50
10	2.0	6.05	150	4.20	115	3.04	90	2.37	75	1.75	55
	5.0	11.46	135	6.17	100	4.06	85	3.08	70	2.26	55
	10	15.45	127	7.08	95	4.56	80	3.41	70	2.50	55
	20	18.35	120	7.57	90	4.80	75	3.58	65	2.61	55
	30	19.12	115	7.63	90	4.79	75	3.56	65	2.60	55

FIGURE 7 – S_{12} PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
V_{CE} (Volts)	I_C (mA)	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ
5.0	2.0	0.04	70	0.09	50	0.11	50	0.12	50	0.16	50
	5.0	0.04	70	0.07	60	0.11	60	0.14	60	0.19	55
	10	0.03	70	0.07	70	0.11	65	0.15	65	0.20	55
	20	0.03	75	0.07	70	0.12	70	0.15	65	0.21	55
	30	0.03	75	0.07	70	0.12	70	0.16	65	0.21	57
10	2.0	0.03	70	0.07	55	0.09	50	0.10	50	0.13	55
	5.0	0.03	70	0.06	60	0.09	65	0.12	60	0.15	60
	10	0.03	70	0.06	65	0.09	65	0.12	65	0.17	60
	20	0.03	75	0.06	70	0.09	70	0.13	65	0.18	60
	30	0.03	75	0.06	70	0.10	70	0.13	65	0.17	60

MRF931

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CBO}	10	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Peak	I_C	5.0	mAdc
Total Device Dissipation @ T_A = 100°C Derate above 100°C	P_D	50 1.0	mW mW/°C
Junction Temperature	T_J	+150	°C
Storage Temperature	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.1 mAdc, I_B = 0)	$V_{(BR)CEO}$	5.0	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	$V_{(BR)CBO}$	10	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.25 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	—	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_E = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	f_T	—	3.0	—	GHz
Collector-Base Capacitance (V_{CB} = 1.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.35	0.5	pF
FUNCTIONAL TEST					
Noise Figure (I_E = 0.25 mAdc, V_{CE} = 1.0 Vdc, f = 0.5 GHz) (I_E = 0.25 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	NF	 — —	 3.8 4.3	 — —	dB
Power Gain at Optimum Noise Figure (I_E = 0.25 mAdc, V_{CE} = 1.0 Vdc, f = 0.5 GHz) (I_E = 0.25 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	G_{NF}	 — —	 16 10	 — —	dB
Transducer Power Gain (I_E = 0.5 mAdc, V_{CE} = 1.0 Vdc, f = 0.5 GHz) (I_E = 0.5 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	G_T	 — —	 18 12	 — —	dB

FIGURE 1 — POWER DERATING

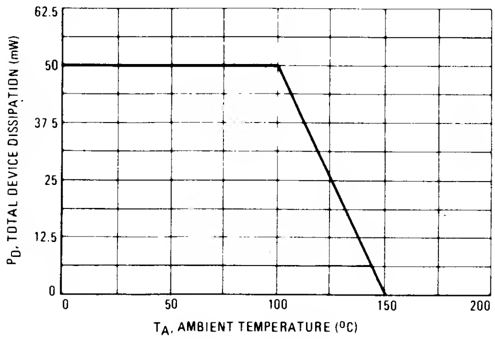


FIGURE 2 — TRANSDUCER POWER GAIN AND NOISE FIGURE versus FREQUENCY

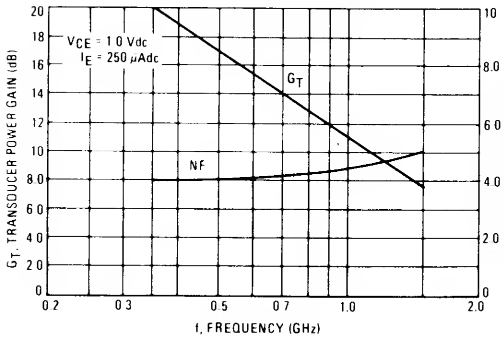
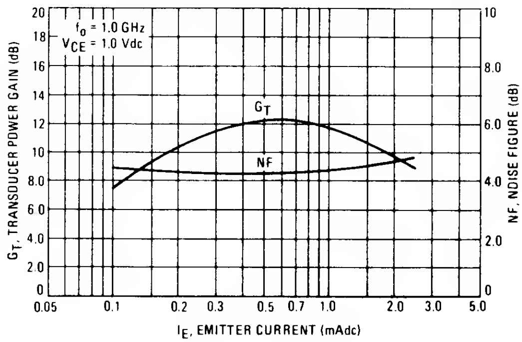


FIGURE 3 — TRANSDUCER POWER GAIN AND NOISE FIGURE versus EMITTER CURRENT



7

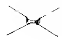
MRF966

CASE 317-01, STYLE 1

DUAL GATE GaAs FET

N-CHANNEL

MRF967



CASE 358-01, STYLE 2

DUAL GATE GaAs FET

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	MRF966	MRF967	Unit
Drain-Source Voltage	V_{DS}	10	10	Vdc
Gate-Source Voltage — Reverse	V_{G1S}	−8.0 −8.0	−8.0 −8.0	Vdc
Gate-Source Voltage — Forward	V_{G1S} V_{G2S}	+1.0 +1.0	+1.0 +1.0	Vdc
Drain Current	I_D	60	60	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 350 3.5	 350 3.5	 mW mW/°C
Junction Temperature Range	T_J	−65 to +125	−65 to +125	°C
Storage Channel Temperature Range	T_{stg}	−65 to +125	−65 to +125	°C

Handling and Packaging — MES devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MES devices should be observed.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{G1S} = V_{G2S} = −4.0 Vdc, I_D = 100 μA)	$V_{(BR)DSX}$	10	—	—	Vdc
Gate 1 Leakage Current (V_{G1S} = −5.0 Vdc, V_{G2S} = V_{DS} = 0)	I_{G1SS}	—	—	10	μAdc
Gate 2 Leakage Current (V_{G2S} = −5.0 Vdc, V_{G1S} = V_{DS} = 0)	I_{G2SS}	—	—	10	μAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 5.0 Vdc, V_{G2S} = 0)	$V_{G1S(off)}$	−2.0	—	−4.5	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 5.0 Vdc, V_{G1S} = 0)	$V_{G2S(off)}$	−2.0	—	−4.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V_{DS} = 5.0 Vdc, V_{G1S} = V_{G2S} = 0)	I_{DSS}	30	50	80	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 5.0 Vdc, V_{G2S} = 0, I_D = 10 mA, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	14	20	—	mmhos
Input Capacitance (V_{DS} = 5.0 Vdc, V_{G2S} = 0, I_D = 10 mA, f = 1.0 MHz)	C_{iss}	—	0.45	—	pF
Reverse Transfer Capacitance (V_{DS} = 5.0 Vdc, V_{G2S} = 0, I_D = 10 mA, f = 1.0 MHz)	C_{rss}	—	0.04	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 5.0 Vdc, V_{G2S} = 0(1), I_{DS} = 10 mA, f = 1.0 GHz)	NF	—	1.2	1.5	dB
Common Source Power Gain (V_{DS} = 5.0 Vdc, V_{G2S} = 0(1), I_{DS} = 10 mA, f = 1.0 GHz) MRF967 MRF966	G_{ps}	13 15	15 18	— —	dB
Intermodulation Distortion (V_{DS} = 5.0 Vdc, I_{DS} = 10 mA, f_1 = 995 MHz, f_2 = 1001 MHz, V_{G2} = 0, P_{in} = −40 dBm)	IMD_3	—	−65	—	dB

7

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Linear Power Point(2) (V_{DS} = 5.0 Vdc, I_{DS} = 10 mA, f_1 = 995 MHz, f_2 = 1001 MHz, V_{G2} = 0)	P_L	—	+1.0	—	dBm
Output Power at 1 dB Compression Point (V_{DS} = 5.0 Vdc, I_{DS} = 10 mA, f = 1.0 GHz)	P_{out}	—	10	—	dBm

(1) Data taken using a HP11608A 50 Ω test fixture, Microlab slug tuners, HP11590A bias networks and the HP8970A noise figure meter. Note: V_{G2S} = 0. Refer to Figure 16.

(2) The linear power point is the output power level at which either the signal $2f_1 \pm f_2$ or $2f_2 \pm f_1$ are 30 dB below f_1 or f_2.

TYPICAL CHARACTERISTICS
MRF966

FIGURE 1 — DRAIN CURRENT versus DRAIN-TO-SOURCE VOLTAGE

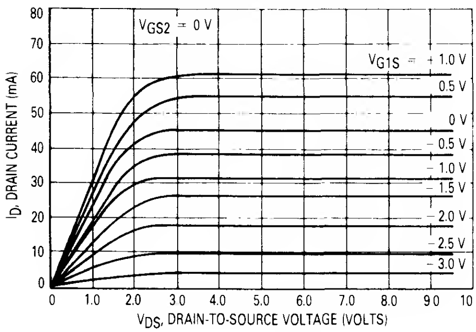


FIGURE 2 — DRAIN CURRENT versus GATE ONE-TO-SOURCE VOLTAGE

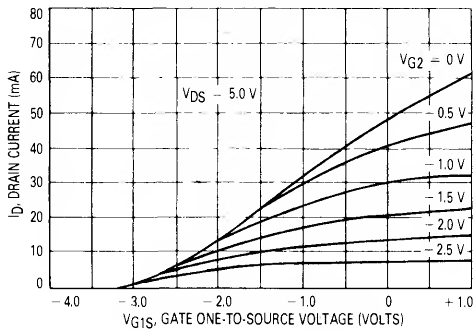


FIGURE 3 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus DRAIN-TO-SOURCE VOLTAGE

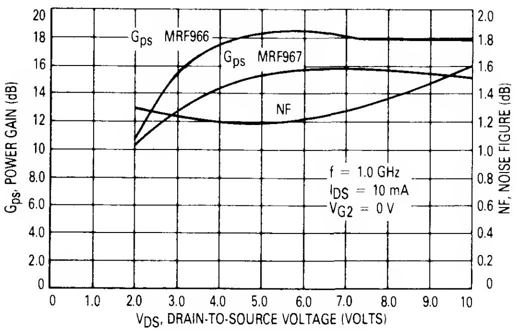


FIGURE 4 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus PERCENT-OF-DRAIN CURRENT

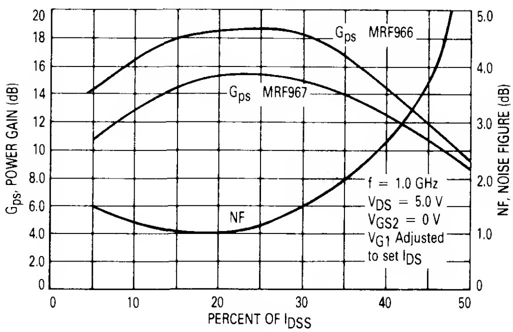


FIGURE 5 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus GATE ONE-TO-SOURCE VOLTAGE

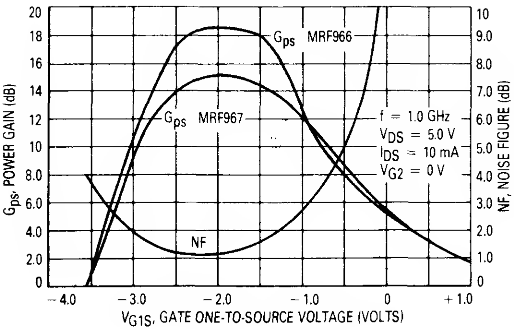


FIGURE 6 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus GATE CONTROL SUPPLY VOLTAGE

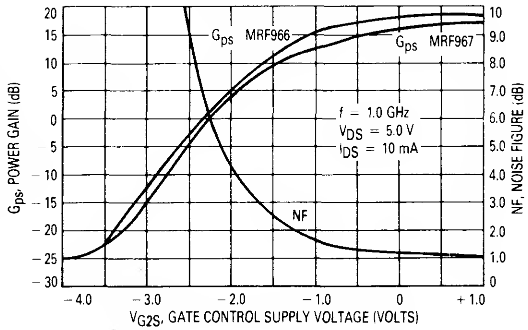


FIGURE 7 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus FREQUENCY

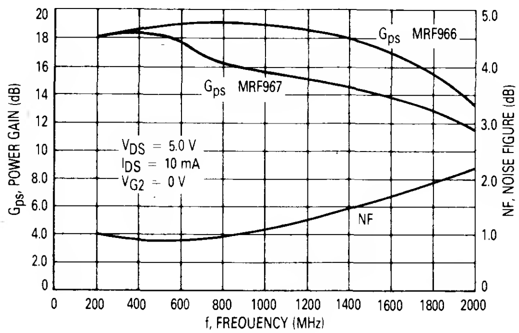


FIGURE 8 — MAXIMUM AVAILABLE GAIN AND STABILITY FACTOR versus FREQUENCY

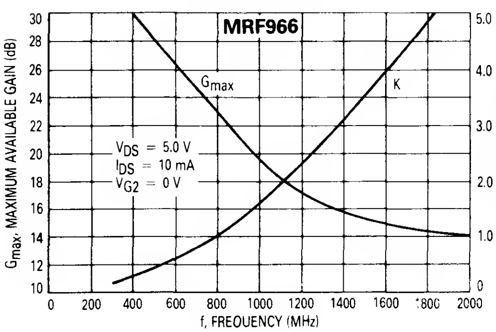


FIGURE 9 — MAXIMUM AVAILABLE GAIN AND STABILITY FACTOR versus FREQUENCY

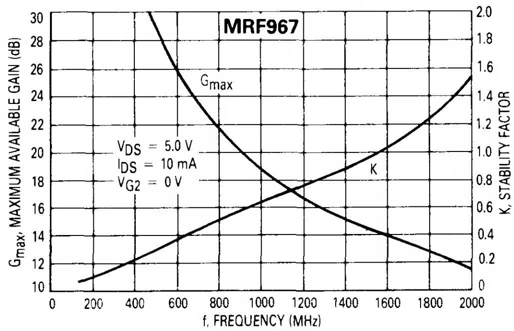


FIGURE 10 — OUTPUT POWER versus INPUT POWER @ 500 MHz

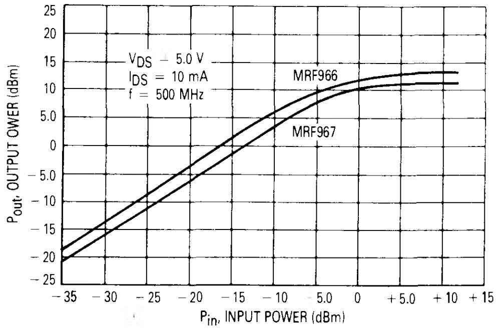
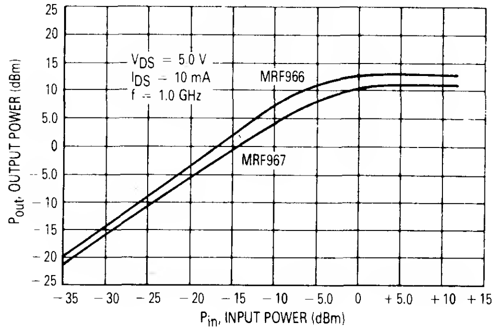


FIGURE 11 — OUTPUT POWER versus INPUT POWER @ 1.0 GHz



TYPICAL CHARACTERISTICS MRF967

FIGURE 12 — THIRD ORDER INTERMODULATION DISTORTION @ 500 MHz

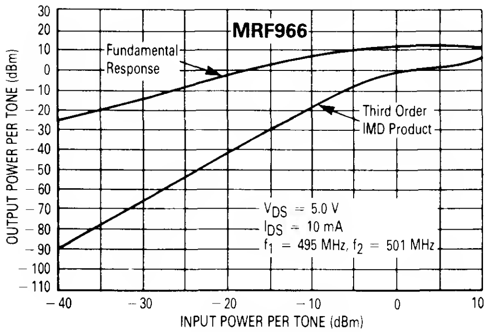


FIGURE 13 — THIRD ORDER INTERMODULATION DISTORTION @ 500 MHz

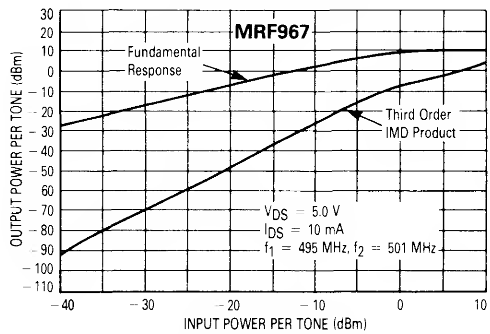


FIGURE 14 — THIRD ORDER INTERMODULATION DISTORTION @ 1.0 GHz

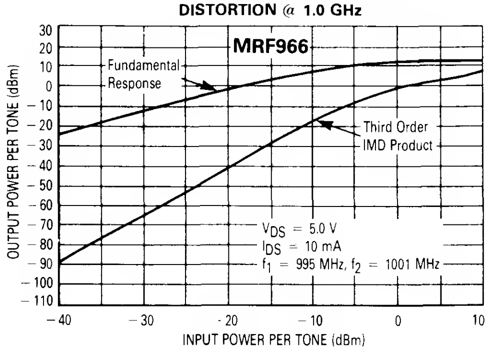


FIGURE 15 — THIRD ORDER INTERMODULATION DISTORTION @ 1.0 GHz

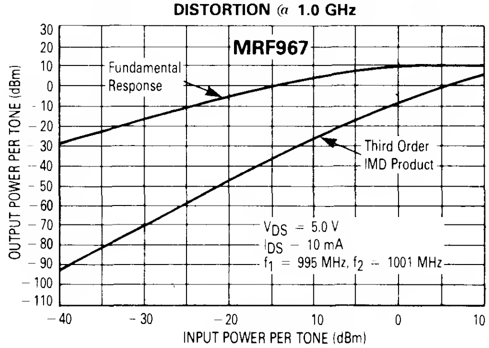
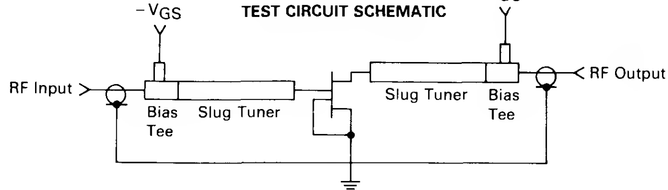
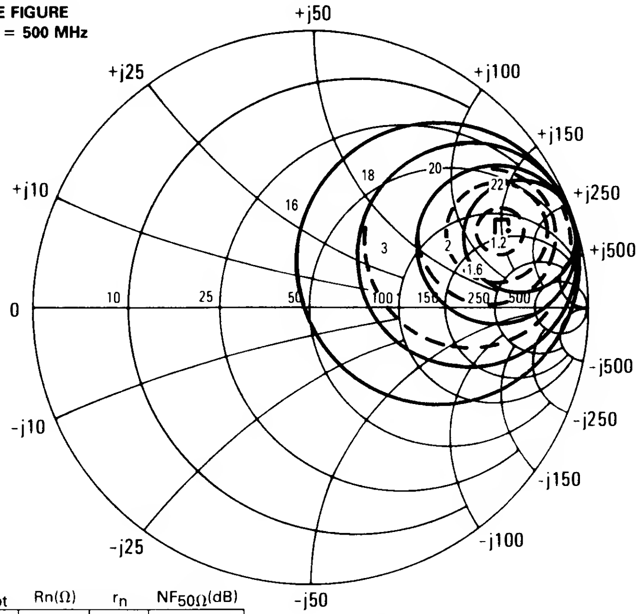


FIGURE 16 — 1.0 GHz TEST CIRCUIT SCHEMATIC



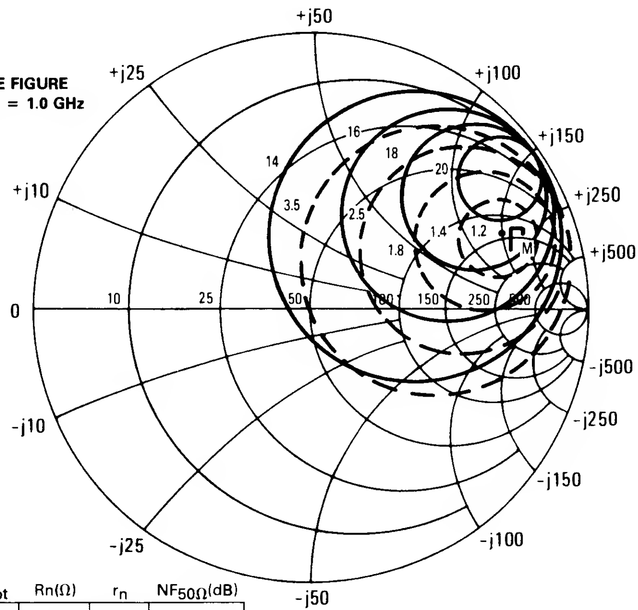
MRF966

FIGURE 17 — CONSTANT GAIN AND NOISE FIGURE CONTOURS AT V_{DS} = 5.0 V, I_{DS} = 10 mA, f = 500 MHz (MATCHED OUTPUT)



f(MHz)	NF_{opt}(dB)	ΓMS NF_{opt}	ΓML NF_{opt}	Rn(Ω)	r_n	$NF_{50\Omega}$(dB)
500	1.0	0.76/22°	0.75/14°	101.5	2.03	4.5

FIGURE 18 — CONSTANT GAIN AND NOISE FIGURE CONTOURS AT V_{DS} = 5.0 V, I_{DS} = 10 mA, f = 1.0 GHz (MATCHED OUTPUT)



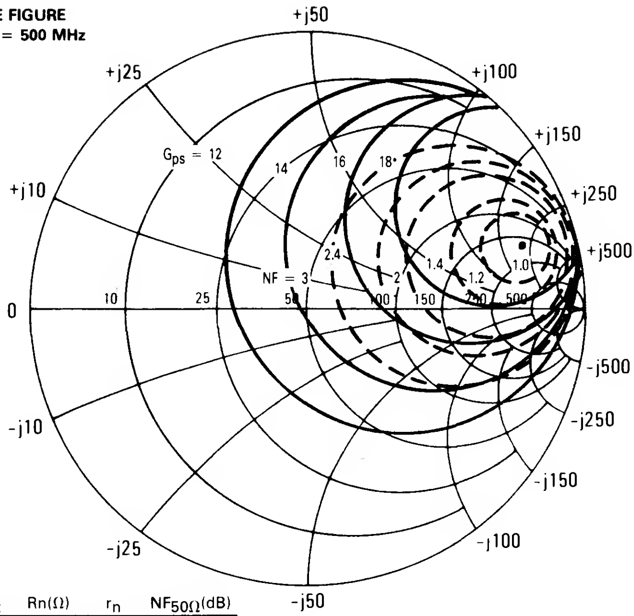
f(MHz)	NF_{opt}(dB)	ΓMS NF_{opt}	ΓML NF_{opt}	Rn(Ω)	r_n	$NF_{50\Omega}$(dB)
1000	1.2	0.74/21°	0.77/12°	63	1.26	3.5

MRF966 COMMON-SOURCE S-PARAMETERS

V_{DS} (Volts)	I_{DS} (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
3.0	5.0	200	0.99	−4.0	1.10	171	0.002	94	0.96	−3.0
		500	0.96	−12	1.07	155	0.004	79	0.95	−8.0
		1000	0.92	−24	1.06	134	0.008	71	0.93	−17
		1500	0.84	−38	1.00	112	0.008	70	0.90	−26
		2000	0.71	−49	0.96	90	0.006	100	0.86	−34
	10	200	0.99	−5.0	1.31	171	0.002	82	0.95	−3.0
		500	0.96	−13	1.28	155	0.005	78	0.94	−8.0
		1000	0.90	−26	1.25	134	0.008	73	0.91	−17
		1500	0.81	−40	1.19	112	0.009	72	0.88	−27
		2000	0.67	−51	1.08	90	0.008	100	0.84	−35
	15	200	0.99	−5.0	1.34	170	0.002	92	0.93	−3.0
		500	0.96	−14	1.30	155	0.005	78	0.93	−8.0
		1000	0.90	−27	1.29	133	0.009	73	0.91	−17
		1500	0.79	−42	1.23	111	0.009	74	0.87	−26
		2000	0.65	−53	1.12	88	0.009	98	0.83	−34
	20	200	0.99	−5.0	1.24	170	0.002	95	0.91	−3.0
		500	0.96	−15	1.21	154	0.006	80	0.90	−8.0
		1000	0.89	−29	1.20	131	0.010	74	0.88	−17
		1500	0.79	−45	1.17	108	0.011	74	0.85	−26
		2000	0.64	−57	1.08	84	0.012	94	0.83	−33
5.0	5.0	200	0.99	−5.0	1.33	170	0.001	84	0.97	−3.0
		500	0.98	−13	1.29	156	0.004	70	0.97	−9.0
		1000	0.90	−27	1.25	132	0.006	78	0.95	−17
		1500	0.81	−40	1.19	112	0.005	73	0.91	−25
		2000	0.68	−51	1.00	94	0.006	115	0.88	−35
	10	200	0.99	−5.0	1.66	170	0.001	75	0.97	−3.0
		500	0.97	−14	1.63	156	0.004	76	0.96	−9.0
		1000	0.89	−28	1.56	132	0.006	79	0.94	−17
		1500	0.78	−41	1.47	112	0.005	80	0.90	−25
		2000	0.65	−52	1.23	94	0.007	121	0.87	−35
	15	200	0.99	−5.0	1.84	170	0.001	78	0.96	−3.0
		500	0.97	−14	1.80	155	0.004	72	0.95	−8.0
		100	0.89	−29	1.71	131	0.006	79	0.94	−17
		1500	0.77	−42	1.61	110	0.005	83	0.90	−25
		2000	0.63	−52	1.34	93	0.007	119	0.87	−34
	20	200	0.99	−5.0	1.89	170	0.001	71	0.96	−3.0
		500	0.97	−15	1.84	155	0.004	78	0.95	−9.0
		1000	0.87	−30	1.75	130	0.006	80	0.93	−17
		1500	0.75	−43	1.64	109	0.006	84	0.90	−24
		2000	0.61	−54	1.37	91	0.008	123	0.87	−34

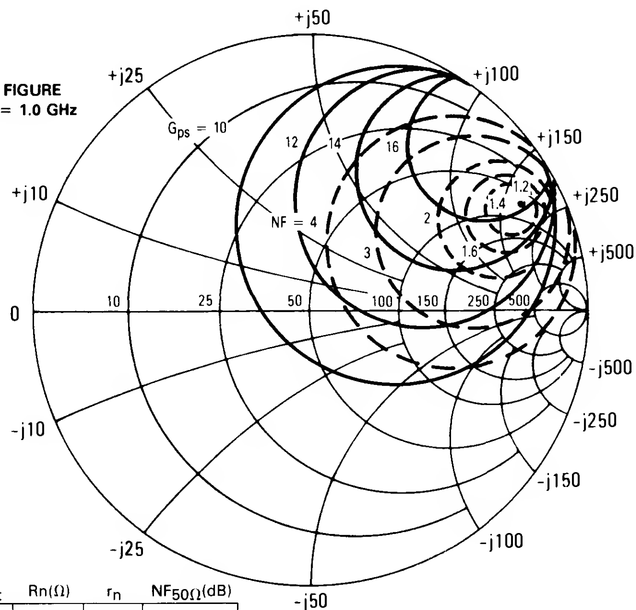
MRF967

FIGURE 19 — CONSTANT GAIN AND NOISE FIGURE CONTOURS AT V_{DS} = 5.0 V, I_{DS} = 10 mA, f = 500 MHz (MATCHED OUTPUT)



f(MHz)	NF_{opt}(dB)	ΓMS NF_{opt}	ΓML NF_{opt}	Rn(Ω)	r_n	$NF_{50\Omega}$(dB)
500	1.0	0.81/16°	0.76/21°	63	1.26	3.6

FIGURE 20 — CONSTANT GAIN AND NOISE FIGURE CONTOURS AT V_{DS} = 5.0 V, I_{DS} = 10 mA, f = 1.0 GHz (MATCHED OUTPUT)



f(MHz)	NF_{opt}(dB)	ΓMS NF_{opt}	ΓML NF_{opt}	Rn(Ω)	r_n	$NF_{50\Omega}$(dB)
1000	1.2	0.84/26°	0.82/17°	88.5	1.77	4.6

7

MRF967 COMMON-SOURCE S-PARAMETERS

V_{DS} (Volts)	I_{DS} (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
3.0	5.0	200	0.99	−5	1.19	170	0.005	77	0.96	−4
		500	0.97	−14	1.16	155	0.016	73	0.94	−11
		1000	0.92	−27	1.11	131	0.030	65	0.93	−21
		1500	0.86	−40	1.03	111	0.040	54	0.87	−31
		2000	0.78	−52	0.96	91	0.048	45	0.83	−43
	10	200	0.99	−5	1.47	170	0.006	81	0.95	−4
		500	0.97	−15	1.43	155	0.016	73	0.93	−11
		1000	0.91	−29	1.39	131	0.031	65	0.92	−21
		1500	0.84	−43	1.29	111	0.040	54	0.86	−31
		2000	0.75	−56	1.19	90	0.047	45	0.81	−44
	15	200	1.00	−6	1.50	170	0.006	82	0.93	−4
		500	0.97	−16	1.46	155	0.016	74	0.91	−11
		1000	0.89	−31	1.42	131	0.031	64	0.90	−21
		1500	0.83	−46	1.33	110	0.040	53	0.84	−31
		2000	0.73	−59	1.24	89	0.048	45	0.79	−43
	20	200	1.00	−6	1.33	170	0.007	78	0.90	−3
		500	0.97	−17	1.30	154	0.017	73	0.88	−10
		1000	0.89	−33	1.27	129	0.033	64	0.88	−21
		1500	0.82	−49	1.21	108	0.043	53	0.82	−30
		2000	0.73	−63	1.14	86	0.050	44	0.78	−42
5.0	5.0	200	0.99	−5	1.17	170	0.006	84	0.97	−3
		500	0.97	−14	1.16	155	0.014	76	0.97	−9
		1000	0.93	−27	1.11	131	0.027	65	0.94	−18
		1500	0.87	−28	1.07	110	0.039	57	0.93	−28
		2000	0.79	−53	0.97	91	0.045	50	0.88	−37
	10	200	0.99	−5	1.47	170	0.006	84	0.97	−3
		500	0.97	−15	1.43	156	0.014	76	0.96	−9
		1000	0.92	−29	1.35	132	0.027	65	0.93	−18
		1500	0.85	−44	1.32	111	0.038	57	0.90	−29
		2000	0.77	−56	1.19	91	0.044	49	0.86	−37
	15	200	1.00	−6	1.53	170	0.006	85	0.96	−3
		500	0.98	−15	1.48	156	0.014	77	0.95	−9
		1000	0.91	−29	1.41	131	0.027	64	0.93	−18
		1500	0.85	−46	1.37	110	0.038	57	0.90	−28
		2000	0.75	−58	1.24	90	0.043	49	0.86	−36
	20	200	1.00	−6	1.32	170	0.006	85	0.95	−3
		500	0.98	−16	1.29	155	0.015	76	0.95	−8
		1000	0.91	−32	1.23	129	0.027	64	0.92	−17
		1500	0.88	−49	1.21	107	0.038	55	0.90	−27
		2000	0.75	−62	1.11	87	0.043	48	0.86	−36

MRF8003

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

RF AMPLIFIER TRANSISTOR

NPN SILICON

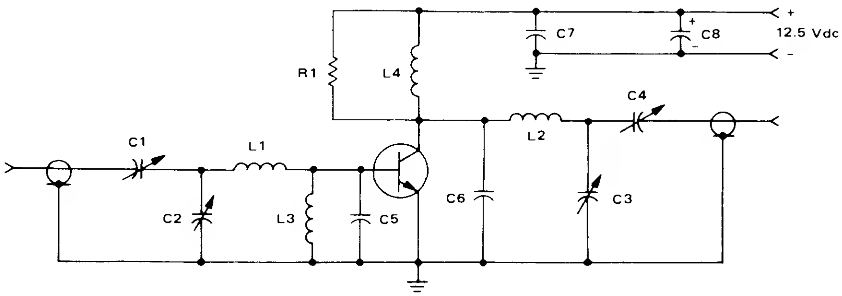
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 0.1 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.5 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 12 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	15	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, f = 27 MHz)	G_{PE}	10	—	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, f = 27 MHz)	η		50		%

FIGURE 1 – 27 MHz TEST CIRCUIT SCHEMATIC



C1, C2, C3, C4	9.0-180 pF ARCO 463 or equivalent
C5	25 pF UNDERWOOD
C6	100 pF UNDERWOOD
C7	1000 pF UNDERWOOD
C8	10 μF ELECTROLYTIC
L1, L2	0.47 μH Molded Coil
L3	VK 200-20/4B RFC
L4	16 Turns No. 26 Wire Closewound on R1
R1	390 Ω, 2 W

7

MRF8004

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C(1) Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.01	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 400 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	10	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	35	70	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (See Figure 1) (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	G_{PE}	10	—	—	dB
Collector Efficiency(2) (See Figure 1) (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	η	62.5	70	—	%
Percentage Up-Modulation(1) (See Figure 1) (f = 27 MHz)	—	—	85	—	%
Parallel Equivalent Input Resistance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	R_{in}	—	21	—	Ohms
Parallel Equivalent Input Capacitance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	C_{in}	—	900	—	pF
Parallel Equivalent Output Capacitance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	C_{out}	—	200	—	pF

(1) Percentage Up-Modulation is measured in the test circuit (Figure 1) by setting the Carrier Power (P_c) to 3.5 Watts with V_{CC} = 12.5 Vdc and noting the power input. Then the Peak Envelope Power (PEP) is noted after doubling the original power input to simulate driver modulation (at a 25% duty cycle for thermal considerations) and raising the V_{CC} to 25 Vdc (to simulate the modulating voltage). Percentage Up-Modulation is then determined by the relation:

$$\text{Percentage Up-Modulation} = \left[\left(\frac{PEP}{P_c}\right)^{1/2} - 1\right] \cdot 100$$

$$(2)\ \eta = \frac{R_F P_{out}}{(V_{CC})(I_C)} \cdot 100$$

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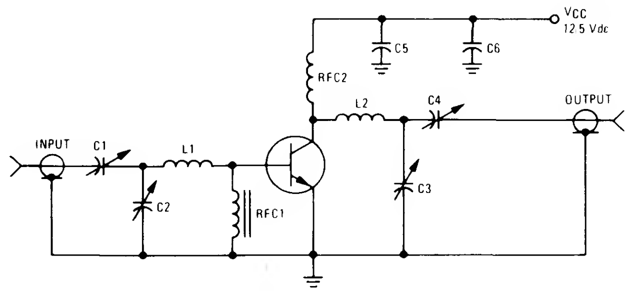
FIGURE 1 – 27 MHz TEST CIRCUIT



C1, C2 9.0-180 pF ARCO 463 or Equivalent
C3, C4 5.0-80 pF ARCO 462 or Equivalent
C5 0.02 μF Ceramic Disc
C6 0.1 μF Ceramic Disc
RFC1 4 Turns #30 Enameled Wire Wound on Ferroxcube Bead Type 56-590-65/3B
RFC2 26 Turns #22 Enameled Wire (2 Layers 13 Turns Each Layer) ¼" Inner Diameter
L1 0.22 μH Molded Choke
L2 0.68 μH Molded Choke

(1)This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

7

FIGURE 2 – CIRCUIT TUNED AT 25 V, 25% DUTY CYCLE, P_{out} = 15 W PEAK

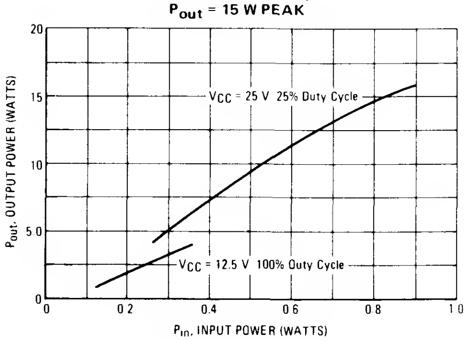
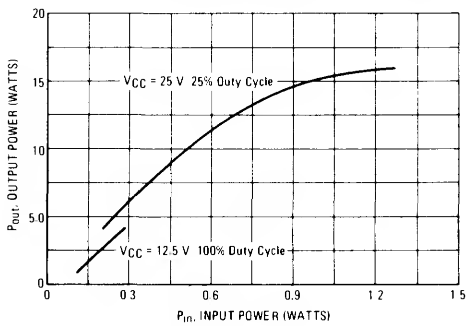


FIGURE 3 – CIRCUIT TUNED AT 12.5 V, P_{out} = 4 W



MWA110
MWA120
MWA130

CASE 31A-01, STYLE 2

GENERAL PURPOSE HYBRID AMPLIFIERS

MAXIMUM RATINGS

Rating	Symbol	Value MWA110	MWA120	MWA130	Unit
RF Input Power	P_{in}	100			mW
DC Supply Current	I_D	25	55	100	mA
Maximum Case Temperature	T_C	125			°C
Storage Temperature Range	T_{stg}	−65 to +200			°C

OPERATING CONDITIONS

Device Voltage	V_D	2.9	5.0	5.5	Vdc
Device Current	I_D	10	25	60	mAdc
Decoupling Impedance	Z_D	1000	1000	330	Ω

ELECTRICAL CHARACTERISTICS (T_C = −25 to +125°C, 50 Ω system and specified operating conditions.)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	0.1	—	400	MHz
Power Gain		G_p	13	14	—	dB
Response Flatness		F	—	0	±1.0	dB
Input VSWR	MWA110/120	—	—	—	2.5:1	—
	MWA130	—	—	—	3:1	—
Output VSWR	MWA110/120/130	—	—	—	2.5:1	—
Output @ 1.0 dB Gain Compression						dBm
	MWA110		—	−2.5	—	
	MWA120		—	+8.2	—	
	MWA130		—	+18	—	
Noise Figure		NF				dB
	MWA110		—	4.0	—	
	MWA120		—	5.5	—	
	MWA130		—	7.0	—	
Reverse Isolation		P_{RI}				dB
	MWA110		—	18.8	—	
	MWA120		—	19.2	—	
	MWA130		—	16.8	—	
Harmonic Output		d_{so}				dB
	MWA110 (P_{out} = −9.0 dBm)		—	−24	—	
	MWA120 (P_{out} = 0 dBm)		—	−34	—	
	MWA130 (P_{out} = +10 dBm)		—	−35	—	

7

FIGURE 1 – DEVICE VOLTAGE versus DEVICE CURRENT

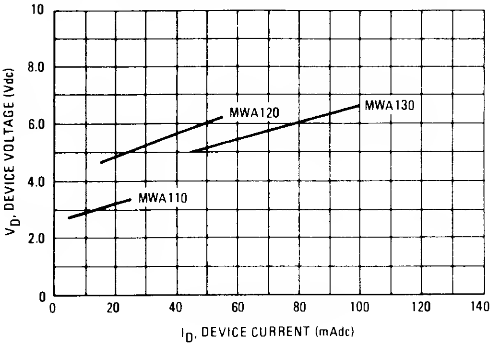


FIGURE 2 – DEVICE CURRENT versus CASE TEMPERATURE

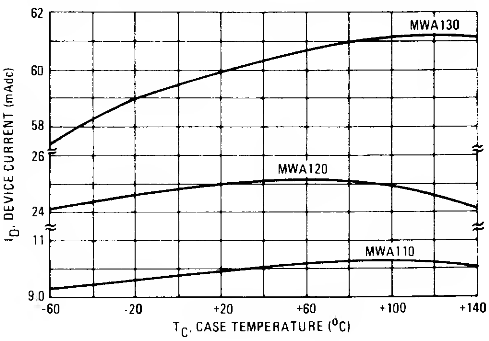


FIGURE 3 – POWER GAIN versus FREQUENCY

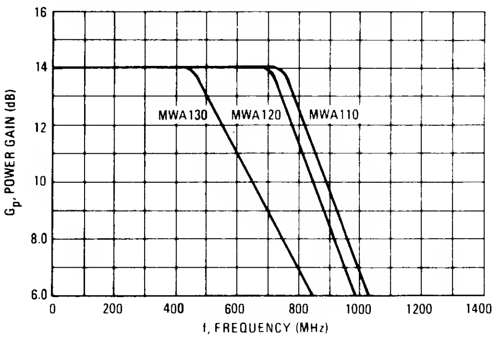


FIGURE 4 – POWER GAIN versus DEVICE CURRENT
f = 400 MHz

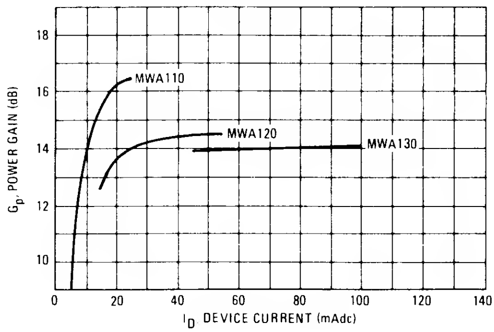


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FIGURE 5 – POWER GAIN versus CASE TEMPERATURE
f = 100 MHz

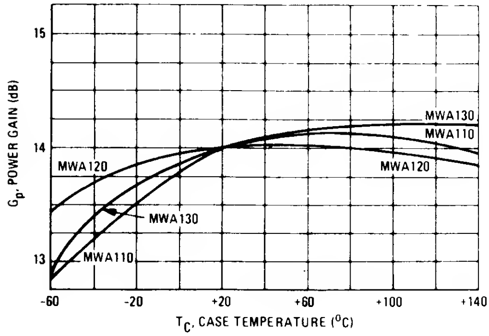

FIGURE 6 – POWER GAIN versus CASE TEMPERATURE
f = 400 MHz

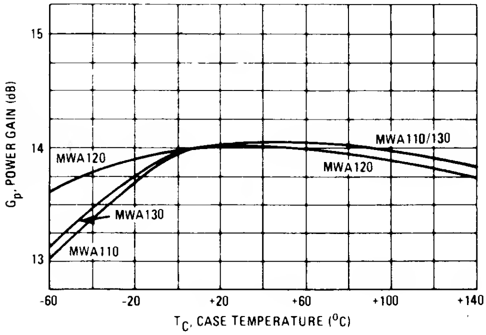

FIGURE 7 – VSWR versus FREQUENCY
MWA110

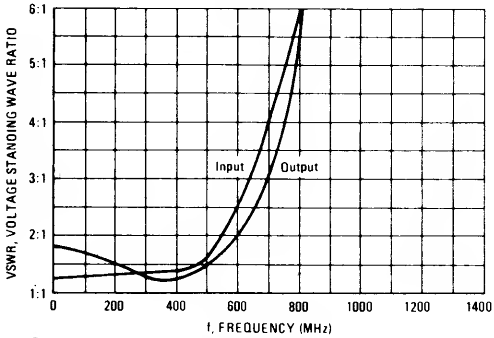

FIGURE 8 – VSWR versus FREQUENCY
MWA120

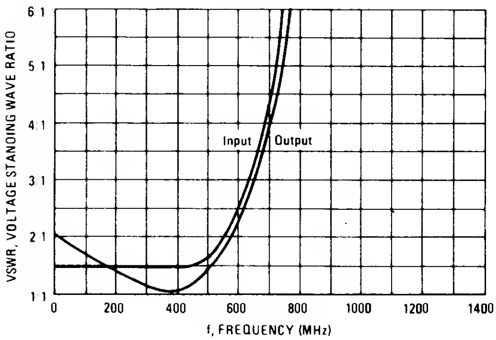

FIGURE 9 – VSWR versus FREQUENCY
MWA130

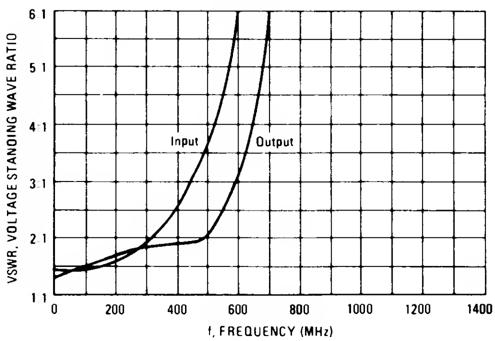

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FIGURE 10 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA110

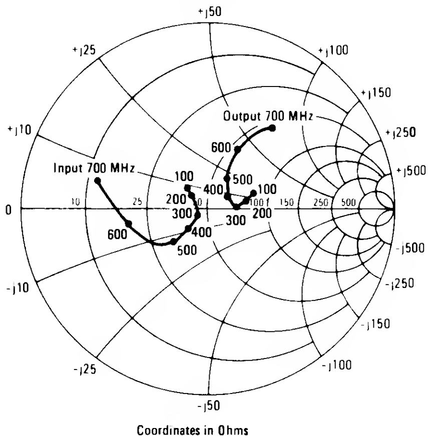

FIGURE 11 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA120

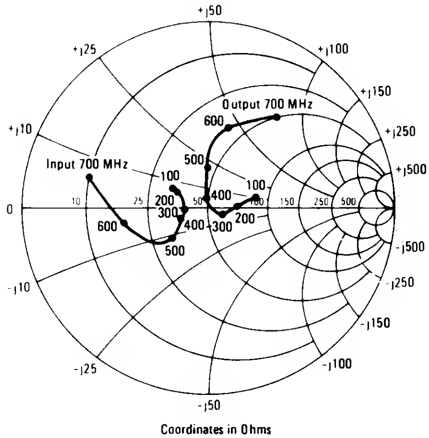

FIGURE 12 – INPUT ANO OUTPUT IMPEDANCE versus FREQUENCY MWA130

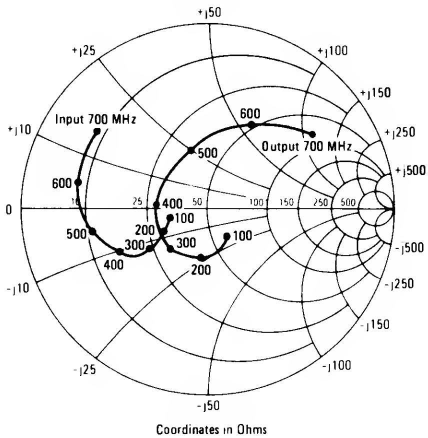

FIGURE 13 – 1.0 dB GAIN COMPRESSION versus FREQUENCY

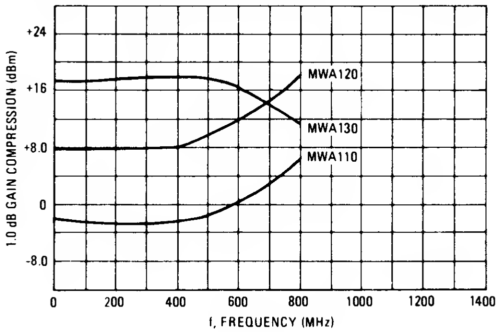

FIGURE 14 – 1.0 dB GAIN COMPRESSION versus DEVICE CURRENT f = 400 MHz

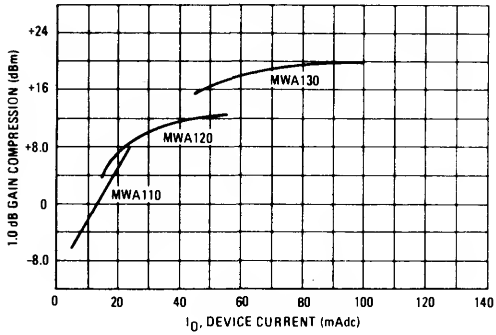

FIGURE 15 – 1.0 dB GAIN COMPRESSION versus CASE TEMPERATURE f = 400 MHz

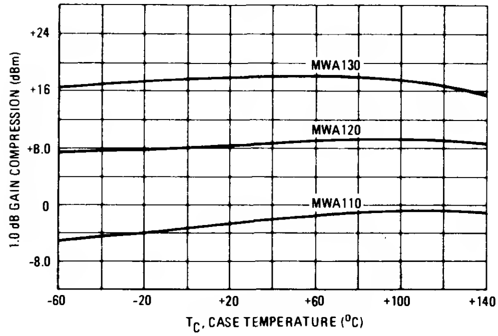

FIGURE 16 – NOISE FIGURE versus FREQUENCY

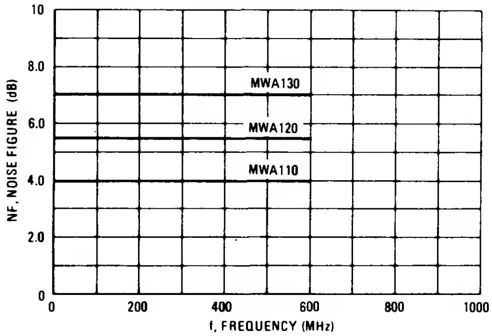

FIGURE 17 – REVERSE ISOLATION versus FREQUENCY

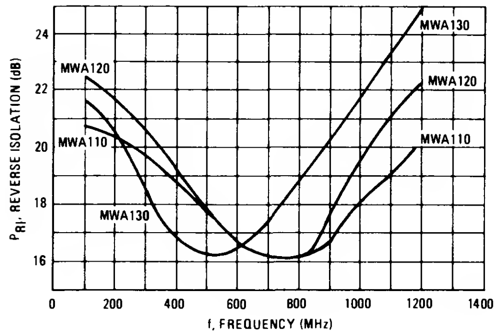

FIGURE 18 – SECOND HARMONIC OUTPUT versus FREQUENCY

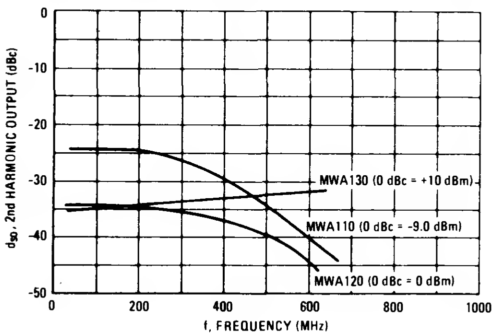

FIGURE 19 – SECOND AND THIRD ORDER INTERCEPT MWA110

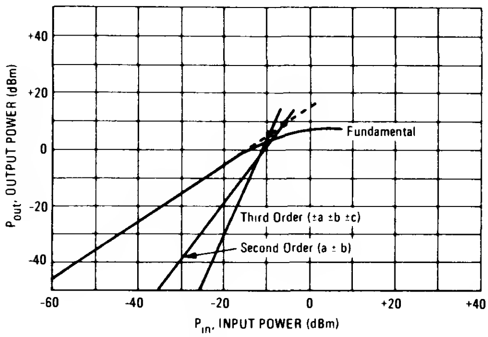

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FIGURE 20 – SECOND AND THIRD ORDER INTERCEPT
MWA120

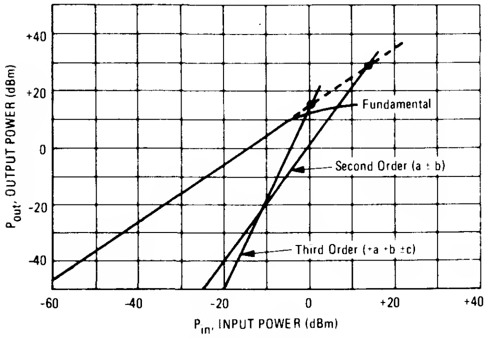

FIGURE 21 – SECOND AND THIRD ORDER INTERCEPT
MWA130

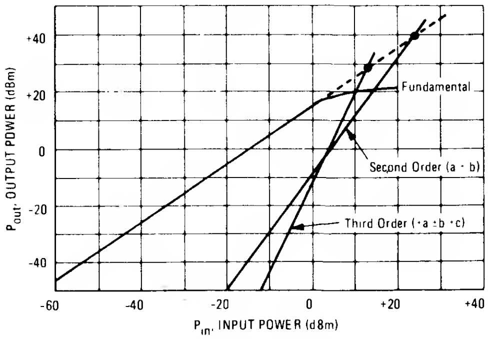

FIGURE 22 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA110

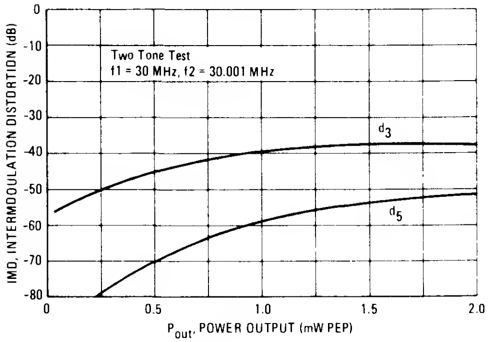

FIGURE 23 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA120

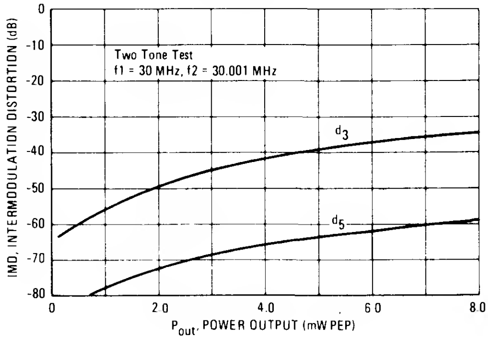

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FIGURE 24 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA130

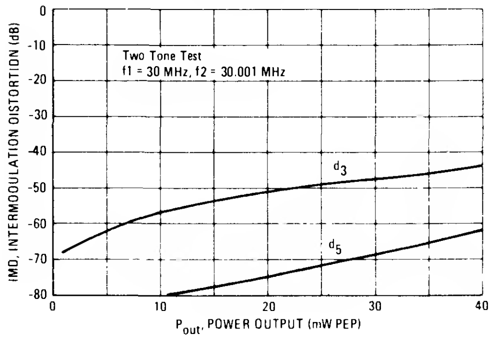
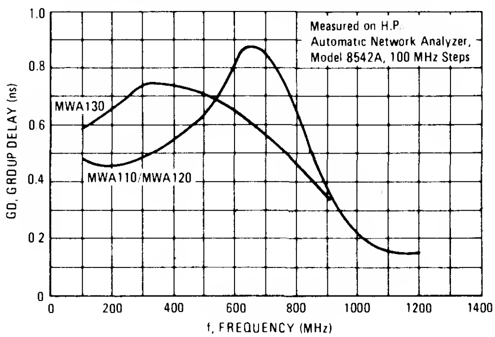


FIGURE 25 – GROUP DELAY versus FREQUENCY



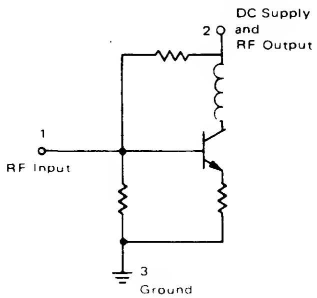
MWA SERIES HYBRID AMPLIFIER APPLICATIONS INFORMATION

The MWA series hybrid amplifiers are designed for wideband general purpose applications in 50 Ω systems. Fully cascadable for any gain combination, operable at voltages as low as 3 Vdc, and external control of the low frequency corner make the MWA amplifiers extremely versatile gain blocks.

Basic Circuit Configuration

Figure 26 shows the basic internal circuit. It is important to note that the specified operating conditions of voltage, current, and external decoupling impedance must be applied to the units in order to achieve the published electrical characteristics.

FIGURE 26 – INTERNAL CIRCUIT



Amplifier Application

The circuit schematic for a simple amplifier design is shown in Figure 27. External to the MWA hybrid amplifier the only components required are:

- Decoupling elements – Bypass Capacitor
  Decoupling Impedance
  (resistor/inductor)
- DC Blocking Capacitors at the RF input and output.

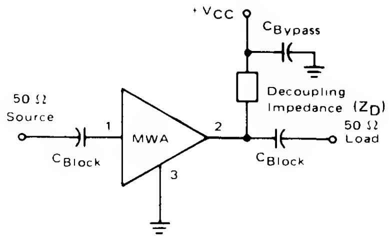
External Decoupling Impedance

In all cases the external bias (decoupling elements) must present an impedance which is large compared to the 50 Ω load impedance to minimize RF gain reduction. The loss in gain due to the decoupling impedance is given by the equation:

$$\text{Loss} = 20\ \text{Log}\ \frac{Z_D}{Z_D + 25}\ \text{dB}$$

where Z_D = decoupling impedance in ohms. For example, if Z_D = 1 kΩ, Loss = 0.214 dB.

FIGURE 27 – AMPLIFIER SCHEMATIC DIAGRAM



Supply Voltage

The value of the external decoupling resistive impedance (R_D) determines the supply voltage ($+V_{CC}$) and is determined by the following equation:

$$V_{CC} = R_D \times I_D + V_D$$

where I_D and V_D are the device current and voltage stated in the data sheet. For example, for MWA110,

$$I_D = 10\ \text{mA}$$
$$V_D = 2.9\ \text{V}$$

and, if R_D = 330 Ω, then

$$V_{CC} \approx 6.2\ \text{V}$$

More commonly V_{CC} is predetermined and R_D may be calculated from:

$$R_D = \frac{V_{CC} - V_D}{I_D}$$

If an RF choke is used for decoupling, then the supply voltage (V_{CC}) required is equal to the device voltage (V_D).

Low Frequency Response

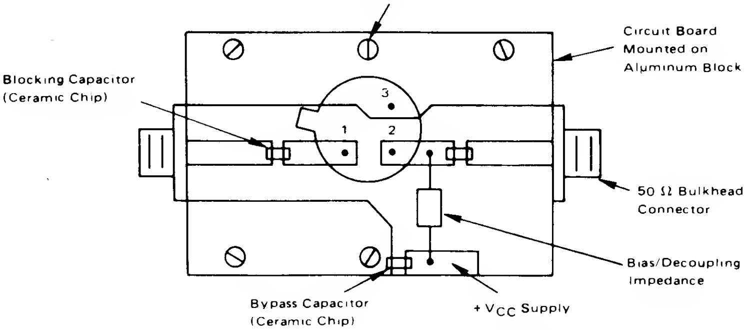
The value of the blocking capacitors determines the low frequency response of the amplifier. The following expression is used to determine the blocking capacitor value to yield a desired 3 dB low frequency corner (f_{LFC}).

$$C_{Block}(\text{Farads}) = \frac{1}{100\,\pi\, f_{LFC}(\text{Hz})}$$

Bypass Capacitor

The reactive impedance of the bypass capacitor should be small compared to the impedance of the decoupling element at the lowest frequency of operation.

FIGURE 28 — TEST FIXTURE



Note: The circuitry indicated is on the underside of the printed circuit board with sockets for the amplifier pins. The case of the amplifier should contact the printed circuit board top surface to ensure effective RF grounding.

Text Fixture

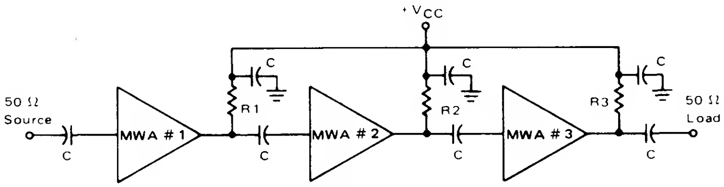
The 50 Ω input/output impedance levels of the MWA hybrids are most easily preserved on a circuit board by using 50 Ω microstrip transmission lines. Figure 28 is an example of a circuit board layout which utilizes microstrip transmission lines in conjunction with other sound RF construction techniques.

The characteristic impedance and corresponding line width of the microstrip are a function of the circuit board dielectric constant and thickness. The table lists appropriate line widths for 50 Ω microstrip lines on commonly used circuit board materials.

MATERIAL TYPE	DIELECTRIC CONSTANT	DIELECTRIC THICKNESS INCHES	LINE WIDTH INCHES
Teflon Fiberglass	2.5	0.03125 0.0625	0.090 0.180
Fiberglass Epoxy	5.0	0.0625	0.100

As in all good RF circuit designs, care should be taken to minimize parasitic lead inductances and to provide adequate grounding.

FIGURE 29 — TYPICAL CASCADE



All Capacitors (C) are 0.018 μF Chip Capacitors

Cascading

The inherent stability of the MWA hybrid modules makes possible the cascading of two or more units with no oscillatory problems. Figure 29 shows a typical 3 hybrid cascade with measured data for 400 MHz and 1000 MHz hybrids.

	Cascade 1	Cascade 2
Frequency Range	0.25 to 400 MHz	0.25 to 1000 MHz
Gain	43.5 dB	20.5 dB
Gain Flatness	±1.0 dB	±0.75 dB
Input VSWR	2.0:1	2.4:1
Output VSWR	1.2:1	2.1:1
V_{CC} Supply	12 Vdc	33 Vdc
I Supply	44 mAdc	150 mAdc
MWA #1	MWA110	MWA320
MWA #2	MWA110	MWA330
MWA #3	MWA120	MWA330
R1	1000 Ω	1000 Ω
R2	1000 Ω	500 Ω
R3	300 Ω	500 Ω

MWA210
MWA220
MWA230

CASE 31A-01, STYLE 2

GENERAL PURPOSE HYBRID AMPLIFIERS

MAXIMUM RATINGS

Rating	Symbol	Value MWA210	Value MWA220	Value MWA230	Unit
RF Input Power	P_{in}	100			mW
DC Supply Current	I_D	25	55	100	mA
Maximum Case Temperature	T_C	125			°C
Storage Temperature Range	T_{stg}	−65 to +200			°C

OPERATING CONDITIONS

Device Voltage	V_D	1.75	3.2	4.4	Vdc
Device Current	I_D	10	25	60	mAdc
Decoupling Impedance	Z_D	1000	1000	330	Ω

ELECTRICAL CHARACTERISTICS (T_C = −25 to +100°C, 50 Ω system and specified operating conditions.)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	0.1	—	600	MHz
Power Gain		G_p	9.0	10	—	dB
Response Flatness		F	—	0	±1.0	dB
Input VSWR	MWA210/220	—	—	—	2.5:1	—
	MWA230	—	—	—	3:1	—
Output VSWR	MWA210/220/230	—	—	—	2.5:1	—
Output @ 1.0 dB Gain Compression	MWA210		—	+1.5	—	dBm
	MWA220		—	+10.5	—	
	MWA230		—	+18.5	—	
Noise Figure	MWA210	NF	—	6.0	—	dB
	MWA220		—	6.5	—	
	MWA230		—	7.5	—	
Reverse Isolation	MWA210	P_{RI}	—	13.5	—	dB
	MWA220		—	14.5	—	
	MWA230		—	12.9	—	
Harmonic Output	MWA210 (P_{out} = −9.0 dBm)	d_{so}	—	−29	—	dB
	MWA220 (P_{out} = 0 dBm)		—	−36	—	
	MWA230 (P_{out} = +10 dBm)		—	−36	—	

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FIGURE 1 — DEVICE VOLTAGE versus DEVICE CURRENT

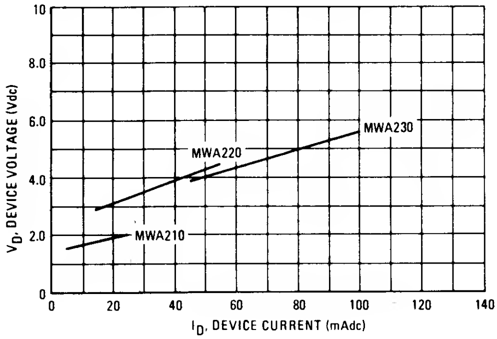

FIGURE 2 — DEVICE CURRENT versus CASE TEMPERATURE

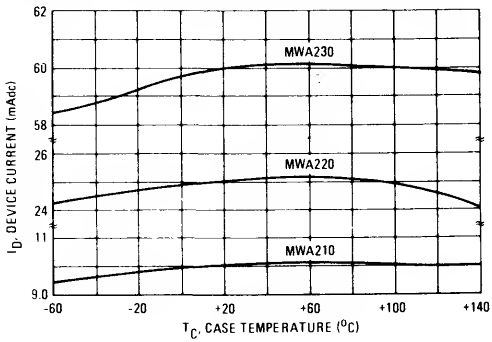

FIGURE 3 — POWER GAIN versus FREQUENCY

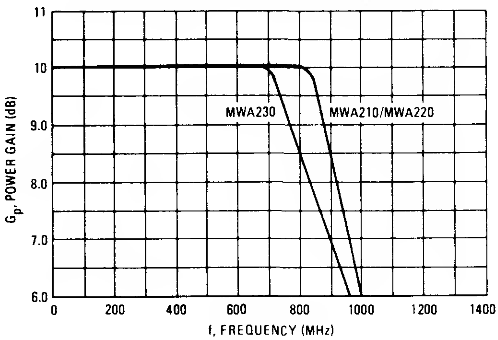

FIGURE 4 — POWER GAIN versus DEVICE CURRENT
f = 600 MHz

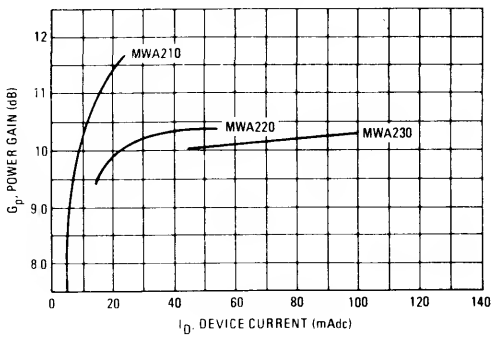

FIGURE 5 – POWER GAIN versus CASE TEMPERATURE
f = 100 MHz

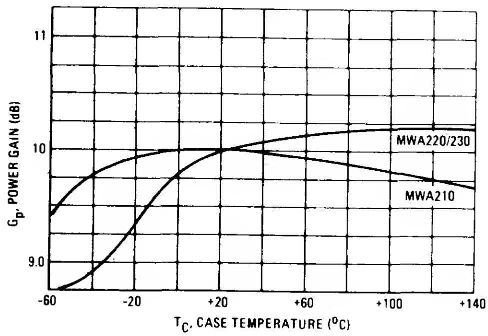

FIGURE 6 – POWER GAIN versus CASE TEMPERATURE
f = 600 MHz

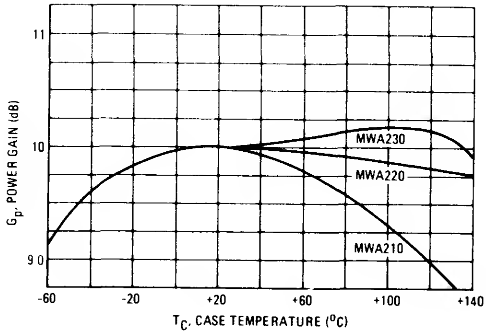

FIGURE 7 – VSWR versus FREQUENCY
MWA210

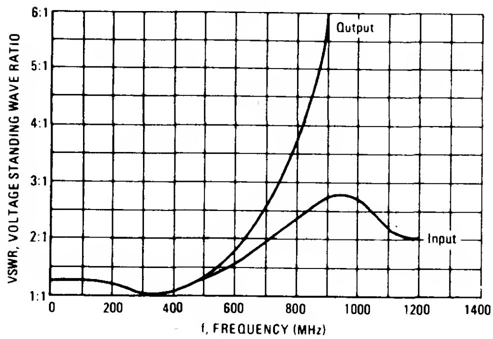

FIGURE 8 – VSWR versus FREQUENCY
MWA220

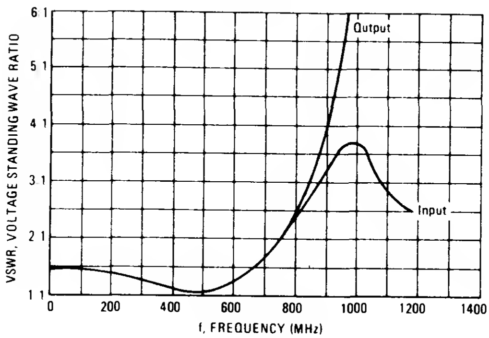

FIGURE 9 – VSWR versus FREQUENCY
MWA230

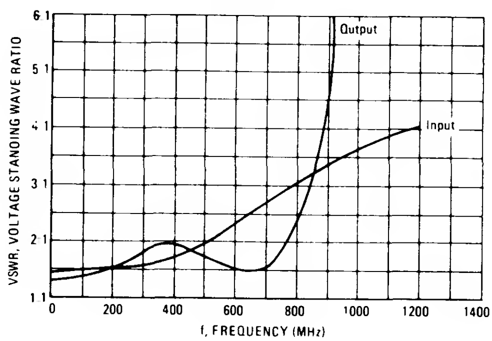

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FIGURE 10 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA210

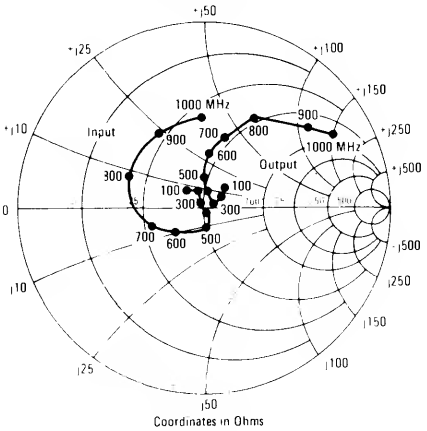


FIGURE 11 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA220

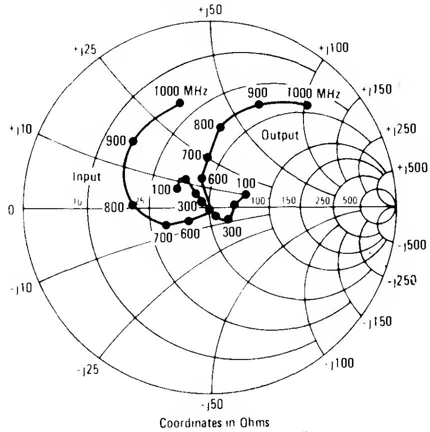


FIGURE 12 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA230

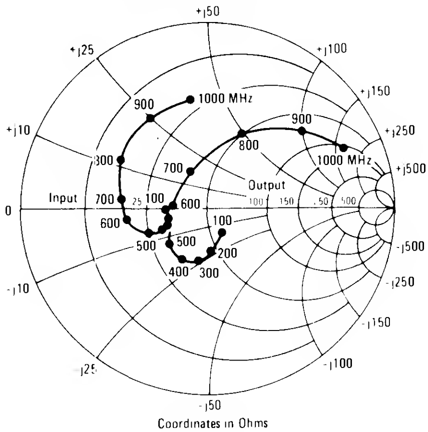
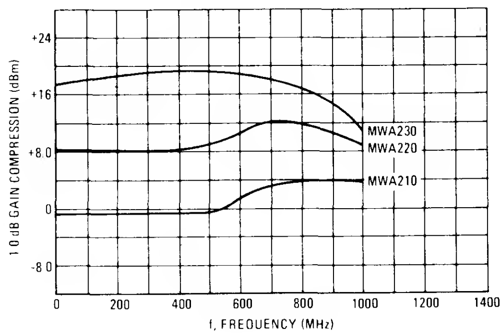


FIGURE 13 – 1.0 dB GAIN COMPRESSION versus FREQUENCY



MWA210 • MWA220 • MWA230

FIGURE 14 – 1.0 dB GAIN COMPRESSION versus DEVICE CURRENT f = 600 MHz

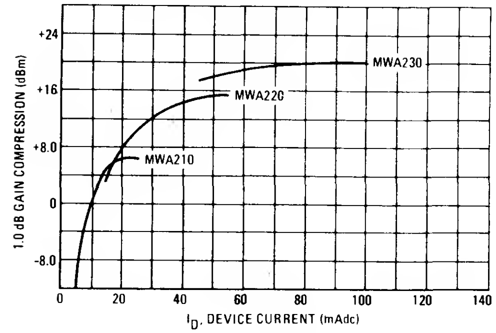


FIGURE 15 – 1.0 dB GAIN COMPRESSION versus CASE TEMPERATURE f = 600 MHz

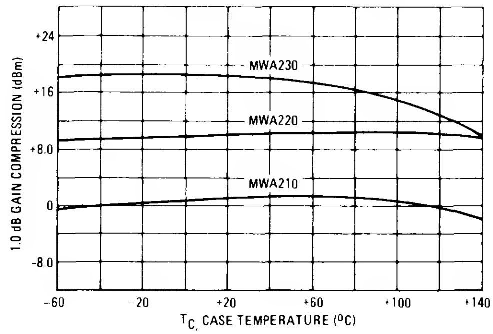


FIGURE 16 – NOISE FIGURE versus FREQUENCY

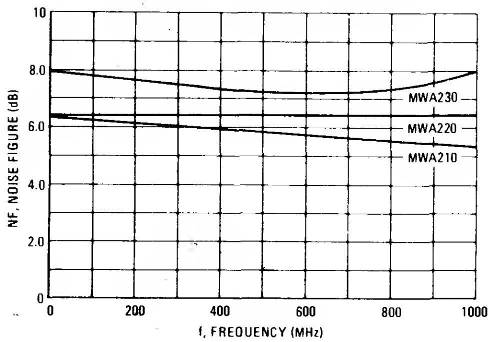


FIGURE 17 – REVERSE ISOLATION versus FREQUENCY

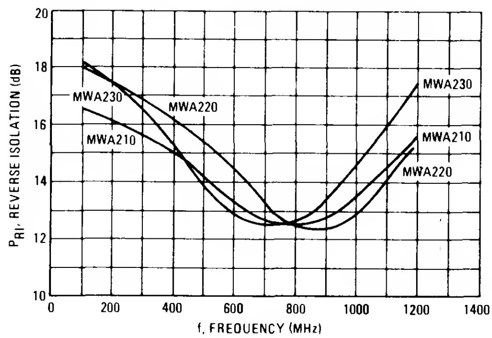


FIGURE 18 – SECOND HARMONIC OUTPUT versus FREQUENCY

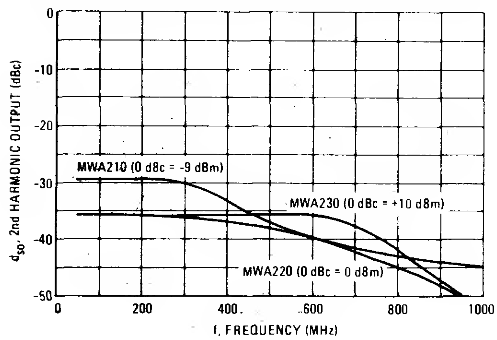


FIGURE 19 – SECOND AND THIRD ORDER INTERCEPT MWA210

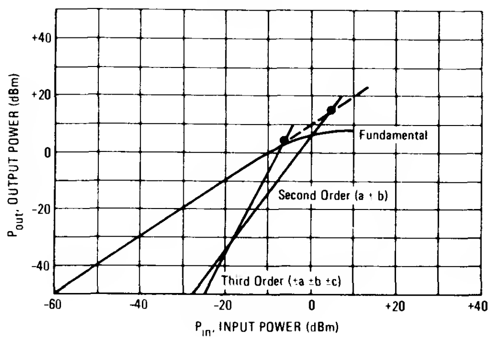


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FIGURE 20 – SECOND AND THIRD ORDER INTERCEPT MWA220

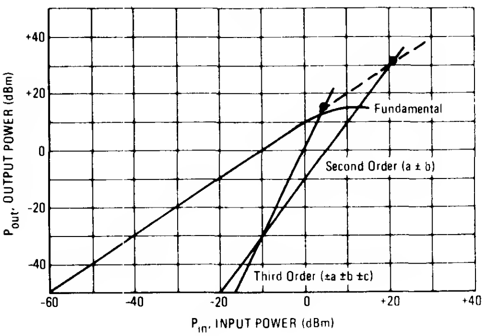


FIGURE 21 – SECOND AND THIRD ORDER INTERCEPT MWA230

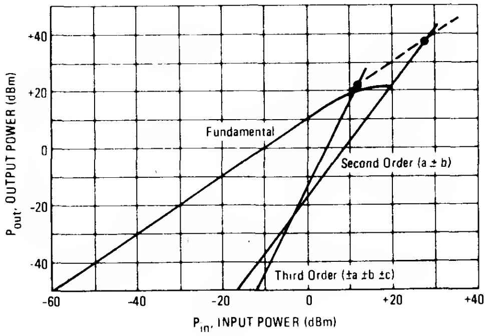


FIGURE 22 – INTERMODULATION DISTORTION versus POWER OUTPUT MWA210

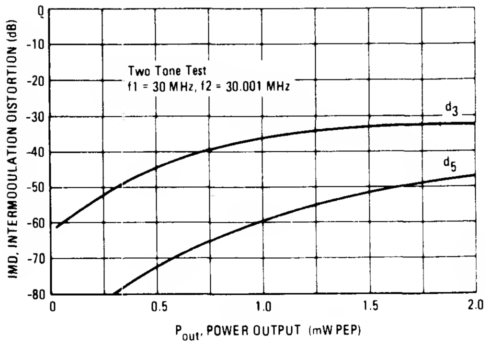


FIGURE 23 – INTERMODULATION DISTORTION versus POWER OUTPUT MWA220

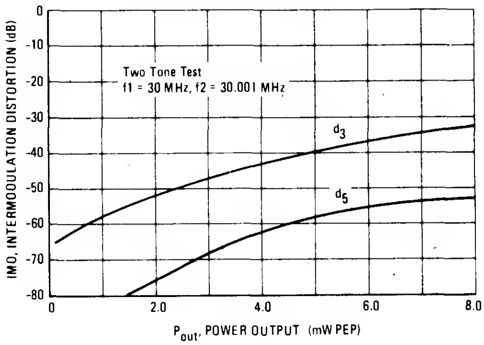


FIGURE 24 – INTERMODULATION DISTORTION versus POWER OUTPUT MWA230

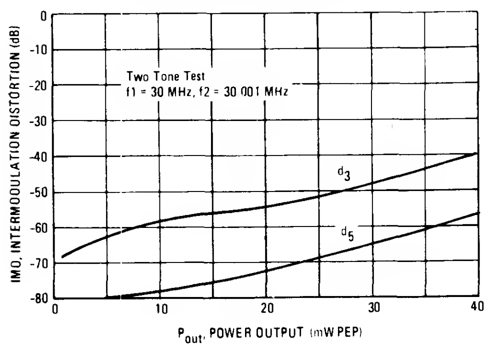
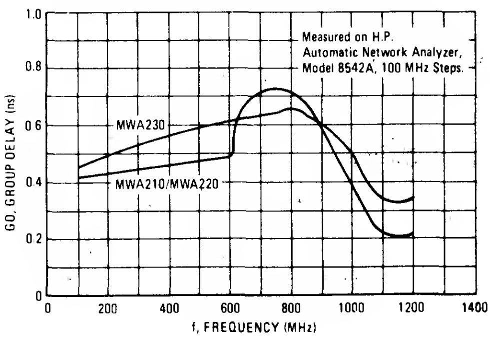


FIGURE 25 – GROUP DELAY versus FREQUENCY



MWA310
MWA320
MWA330

CASE 31A-01, STYLE 2

GENERAL PURPOSE HYBRID AMPLIFIERS

MAXIMUM RATINGS

Rating	Symbol	Value MWA310	Value MWA320	Value MWA330	Unit
RF Input Power	P_{in}	100			mW
DC Supply Current	I_D	25	55	100	mA
Maximum Case Temperature	T_C	125			°C
Storage Temperature Range	T_{stg}	−65 to +200			°C

OPERATING CONDITIONS

Device Voltage	V_D	1.6	2.9	4.0	Vdc
Device Current	I_D	10	25	60	mAdc
Decoupling Impedance	Z_D	1000	1000	330	Ω

ELECTRICAL CHARACTERISTICS (T_C = −25 to +80°C, 50 Ω system and specified operating conditions.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	0.1	—	1000	MHz
Power Gain	G_p				dB
MWA310/320		7.0	8.0	—	
MWA330		—	6.2	—	
Response Flatness	F	—	0	±1.0	dB
Input VSWR	—	—	—	3:1	—
Output VSWR	—	—	—	3:1	—
Output @ 1.0 dB Gain Compression					dBm
MWA310		—	+3.5	—	
MWA320		—	+11.5	—	
MWA330		—	+15.2	—	
Noise Figure	NF				dB
MWA310		—	6.5	—	
MWA320		—	6.7	—	
MWA330		—	9.0	—	
Reverse Isolation	P_{RI}				dB
MWA310		—	10.4	—	
MWA320		—	10.4	—	
MWA330		—	9.0	—	
Harmonic Output	d_{so}				dB
MWA310 (P_{out} = −9.0 dBm)		—	−30	—	
MWA320 (P_{out} = 0 dBm)		—	−38	—	
MWA330 (P_{out} = +10 dBm)		—	−35	—	

7

FIGURE 1 — DEVICE VOLTAGE versus DEVICE CURRENT

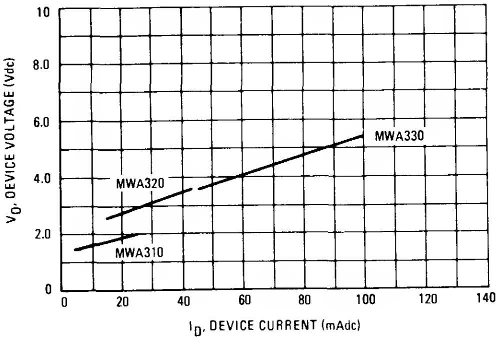


FIGURE 2 — DEVICE CURRENT versus CASE TEMPERATURE

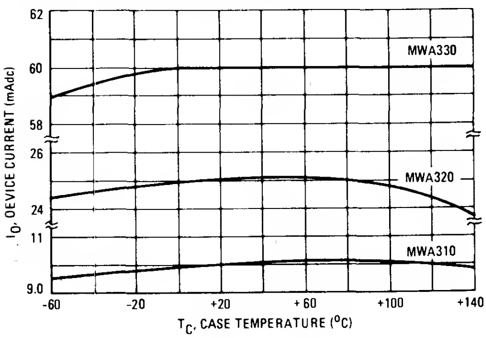


FIGURE 3 — POWER GAIN versus FREQUENCY

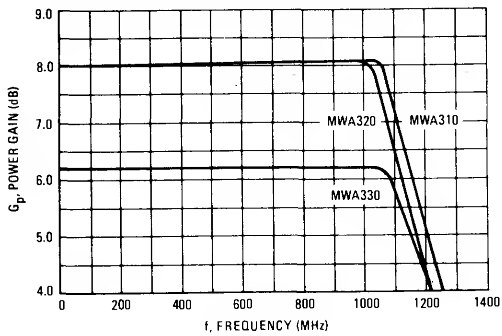
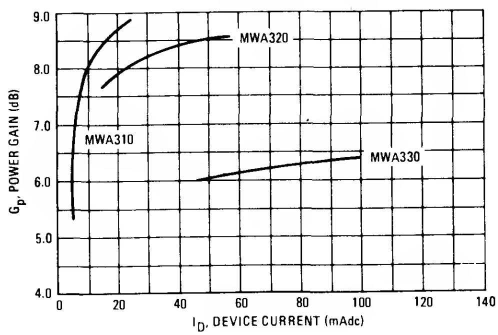


FIGURE 4 — POWER GAIN versus DEVICE CURRENT
f = 1000 MHz



7

FIGURE 5 – POWER GAIN versus CASE TEMPERATURE
f = 100 MHz

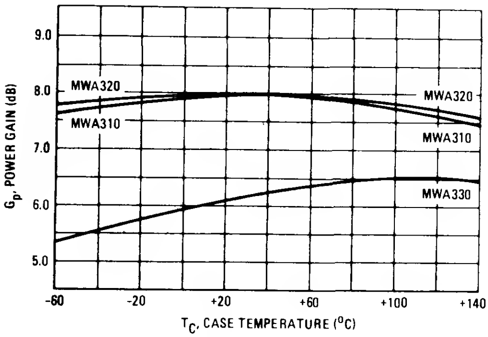


FIGURE 6 – POWER GAIN versus CASE TEMPERATURE
f = 1000 MHz

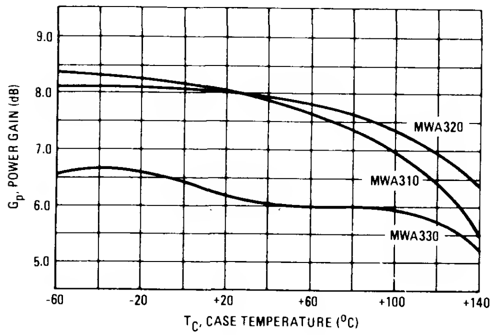


FIGURE 7 – VSWR versus FREQUENCY
MWA310

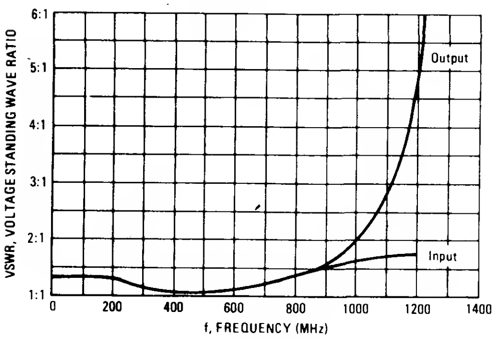


FIGURE 8 – VSWR versus FREQUENCY
MWA320

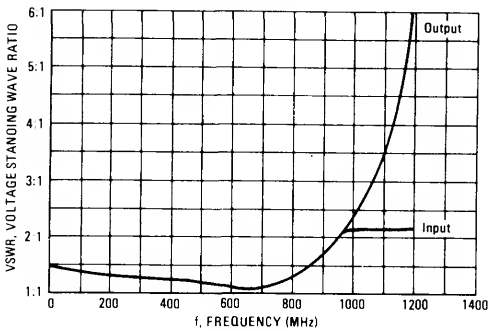


FIGURE 9 – VSWR versus FREQUENCY
MWA330

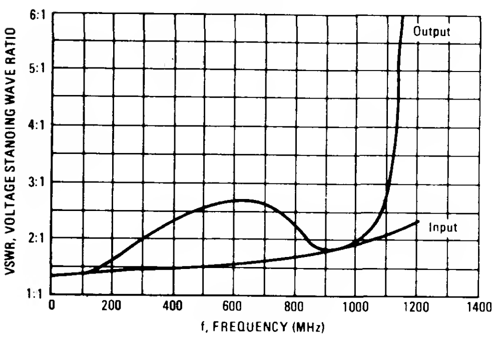
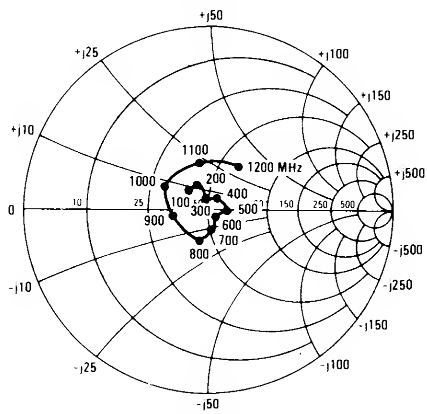


FIGURE 10 – INPUT IMPEDANCE versus FREQUENCY
MWA310



Coordinates in Ohms

FIGURE 11 – OUTPUT IMPEDANCE versus FREQUENCY MWA310

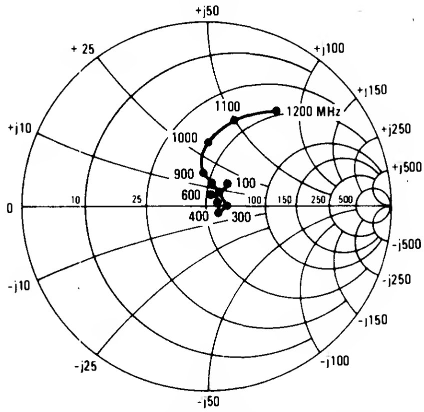


FIGURE 12 – INPUT IMPEDANCE versus FREQUENCY MWA320

Coordinates in Ohms

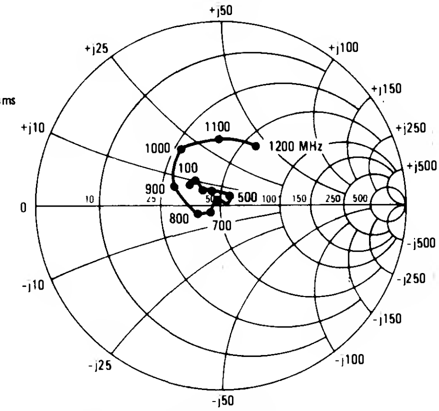


FIGURE 13 – OUTPUT IMPEDANCE versus FREQUENCY MWA320

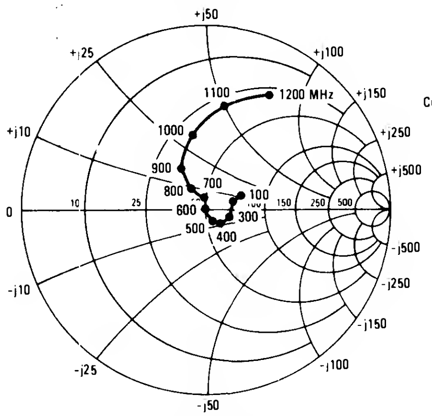


FIGURE 14 – INPUT IMPEDANCE versus FREQUENCY MWA330

Coordinates in Ohms

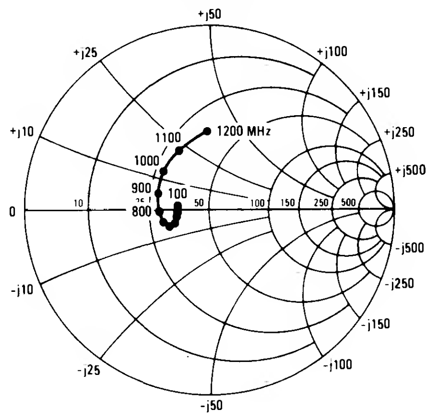


FIGURE 15 – OUTPUT IMPEDANCE versus FREQUENCY MWA330

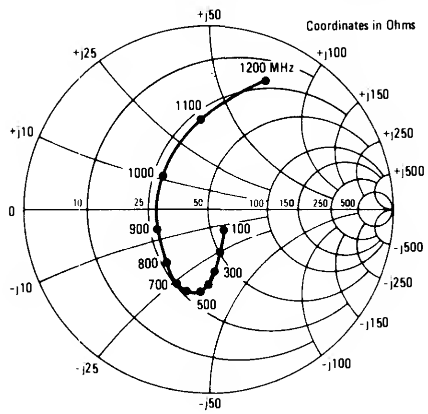


FIGURE 16 – 1.0 dB GAIN COMPRESSION versus FREQUENCY

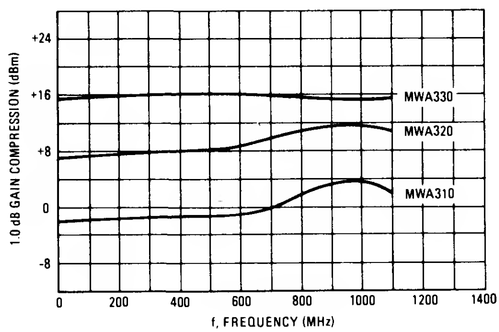


FIGURE 17 – 1.0 dB GAIN COMPRESSION versus DEVICE CURRENT f = 1000 MHz

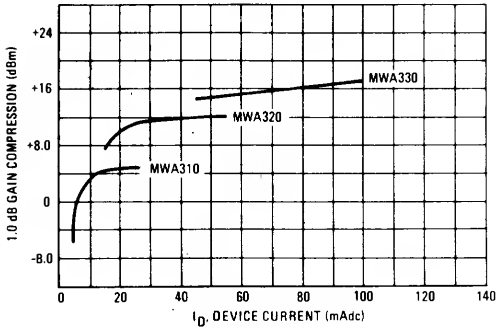


FIGURE 18 – 1.0 dB GAIN COMPRESSION versus CASE TEMPERATURE f = 1000 MHz

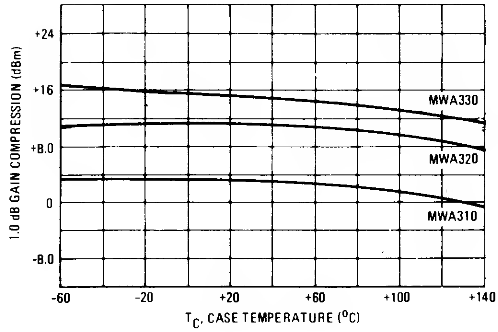


FIGURE 19 – NOISE FIGURE versus FREQUENCY

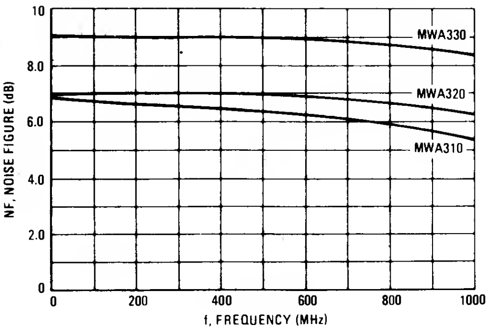


FIGURE 20 – REVERSE ISOLATION versus FREQUENCY

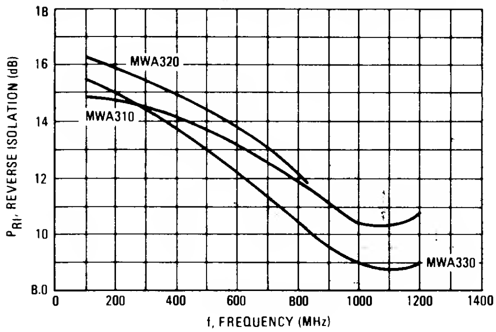


FIGURE 21 – SECOND HARMONIC OUTPUT versus FREQUENCY

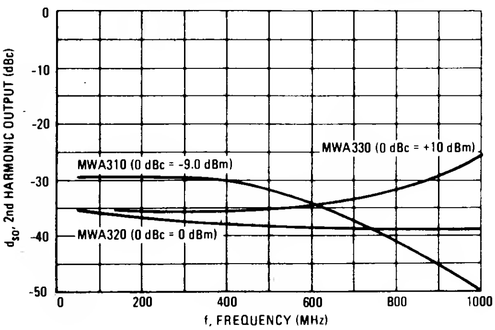


FIGURE 22 – SECOND AND THIRD ORDER INTERCEPT MWA310

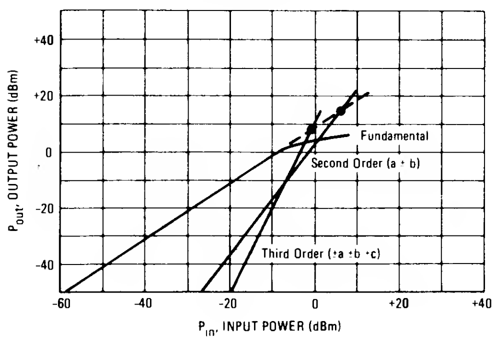


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FIGURE 23 – SECOND AND THIRD ORDER INTERCEPT
MWA320

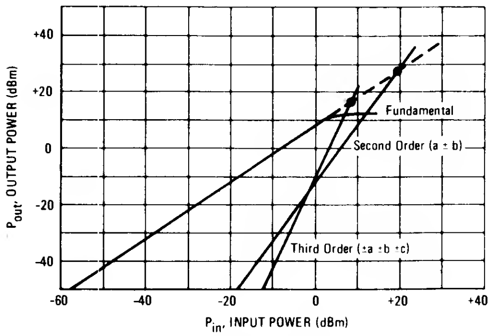


FIGURE 24 – SECOND AND THIRD ORDER INTERCEPT
MWA330

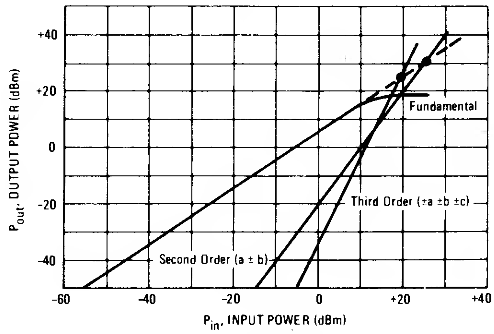


FIGURE 25 – INTERMODULATION DISTORTION versus POWER OUTPUT
MWA310

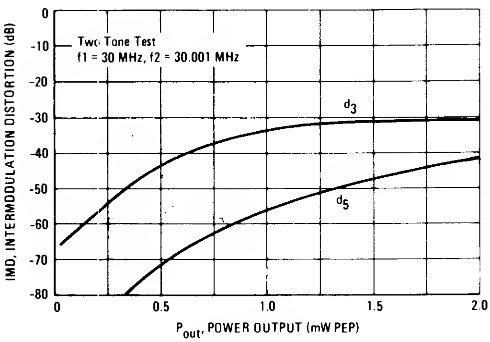


FIGURE 26 – INTERMODULATION DISTORTION versus POWER OUTPUT
MWA320

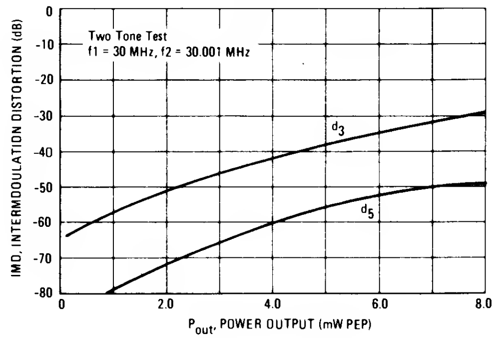


FIGURE 27 – INTERMODULATION DISTORTION versus POWER OUTPUT
MWA330

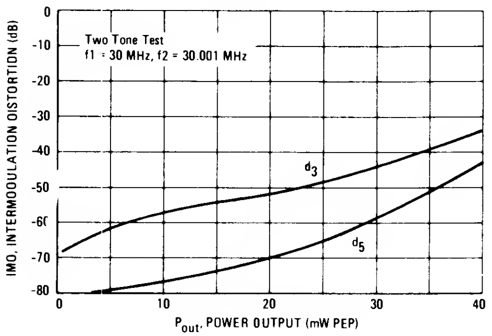
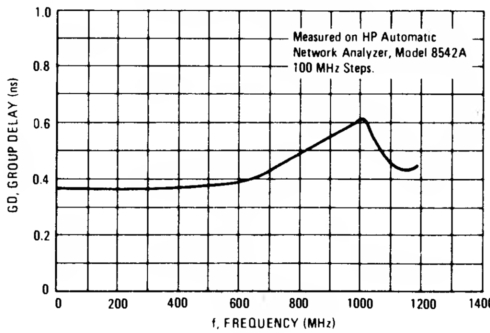


FIGURE 28 – GROUP DELAY versus FREQUENCY
MWA310/MWA320/MWA330



7

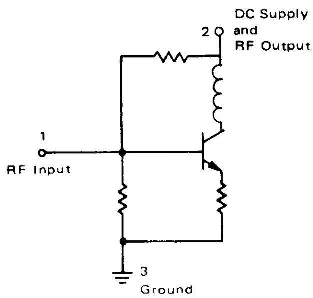
MWA SERIES HYBRID AMPLIFIER APPLICATIONS INFORMATION

The MWA series hybrid amplifiers are designed for wideband general purpose applications in 50 Ω systems. Fully cascadable for any gain combination, operable at voltages as low as 3 Vdc, and external control of the low frequency corner make the MWA amplifiers extremely versatile gain blocks.

Basic Circuit Configuration

Figure 29 shows the basic internal circuit. It is important to note that the specified operating conditions of voltage, current, and external decoupling impedance must be applied to the units in order to achieve the published electrical characteristics.

FIGURE 29 – INTERNAL CIRCUIT



Amplifier Application

The circuit schematic for a simple amplifier design is shown in Figure 30. External to the MWA hybrid amplifier the only components required are:

Decoupling elements – Bypass Capacitor
Decoupling Impedance
(resistor/inductor)

DC Blocking Capacitors at the RF input and output.

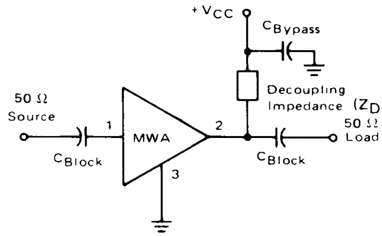
External Decoupling Impedance

In all cases the external bias (decoupling elements) must present an impedance which is large compared to the 50 Ω load impedance to minimize RF gain reduction. The loss in gain due to the decoupling impedance is given by the equation:

$$\text{Loss} = 20 \text{ Log } \frac{Z_D}{Z_D + 25} \text{ dB}$$

where Z_D = decoupling impedance in ohms. For example, if Z_D = 1 kΩ, Loss = 0.214 dB.

FIGURE 30 – AMPLIFIER SCHEMATIC DIAGRAM



Supply Voltage

The value of the external decoupling resistive impedance (R_D) determines the supply voltage ($+V_{CC}$) and is determined by the following equation:

$$V_{CC} = R_D \times I_D + V_D$$

where I_D and V_D are the device current and voltage stated in the data sheet. For example, for MWA110,

$$I_D = 10 \text{ mA}$$
$$V_D = 2.9 \text{ V}$$

and, if R_D = 330 Ω, then

$$V_{CC} = 6.2 \text{ V}$$

More commonly V_{CC} is predetermined and R_D may be calculated from:

$$R_D = \frac{V_{CC} - V_D}{I_D}$$

If an RF choke is used for decoupling, then the supply voltage (V_{CC}) required is equal to the device voltage (V_D).

Low Frequency Response

The value of the blocking capacitors determines the low frequency response of the amplifier. The following expression is used to determine the blocking capacitor value to yield a desired 3 dB low frequency corner (f_{LFC}).

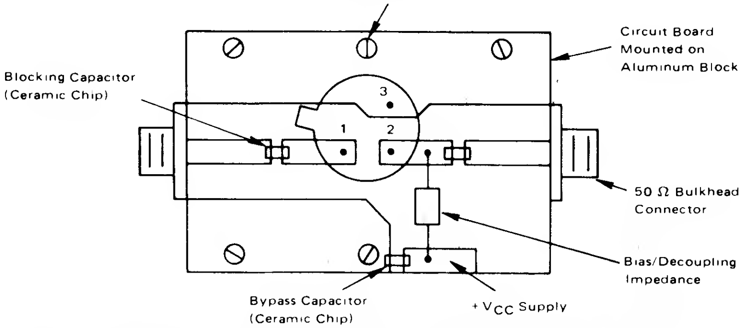
$$C_{Block}(\text{Farads}) = \frac{1}{100\,\pi\, f_{LFC}(\text{Hz})}$$

Bypass Capacitor

The reactive impedance of the bypass capacitor should be small compared to the impedance of the decoupling element at the lowest frequency of operation.

7

FIGURE 31 – TEST FIXTURE



Note The circuitry indicated is on the underside of the printed circuit board with sockets for the amplifier pins. The case of the amplifier should contact the printed circuit board top surface to ensure effective RF grounding.

Text Fixture

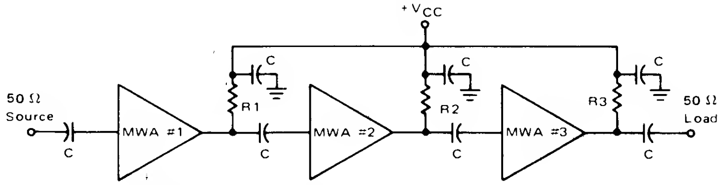
The 50 Ω input/output impedance levels of the MWA hybrids are most easily preserved on a circuit board by using 50 Ω microstrip transmission lines. Figure 31 is an example of a circuit board layout which utilizes microstrip transmission lines in conjunction with other sound RF construction techniques.

The characteristic impedance and corresponding line width of the microstrip are a function of the circuit board dielectric constant and thickness. The table lists appropriate line widths for 50 Ω microstrip lines on commonly used circuit board materials.

MATERIAL TYPE	DIELECTRIC CONSTANT	DIELECTRIC THICKNESS INCHES	LINE WIDTH INCHES
Teflon-Fiberglass	2.5	0.03125 0.0625	0.090 0.180
Fiberglass Epoxy	5.0	0.0625	0.100

As in all good RF circuit designs, care should be taken to minimize parasitic lead inductances and to provide adequate grounding.

FIGURE 32 – TYPICAL CASCADE

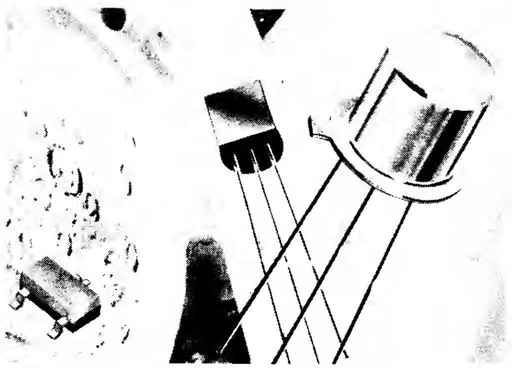


All Capacitors (C) are 0.018 μF Chip Capacitors

Cascading

The inherent stability of the MWA hybrid modules makes possible the cascading of two or more units with no oscillatory problems. Figure 32 shows a typical 3 hybrid cascade with measured data for 400 MHz and 1000 MHz hybrids.

	Cascade 1	Cascade 2
Frequency Range	0.25 to 400 MHz	0.25 to 1000 MHz
Gain	43.5 dB	20.5 dB
Gain Flatness	±1.0 dB	±0.75 dB
Input VSWR	2.0:1	2.4:1
Output VSWR	1.2:1	2.1:1
V_{CC} Supply	12 Vdc	33 Vdc
I Supply	44 mAdc	150 mAdc
MWA #1	MWA110	MWA320
MWA #2	MWA110	MWA330
MWA #3	MWA120	MWA330
R1	1000 Ω	1000 Ω
R2	1000 Ω	500 Ω
R3	300 Ω	500 Ω



The following pages contain information on the various packages referenced on the individual data sheets. Information includes: a picture of the package, dimensions in both millimeters and inches, the various pinout configurations (styles), a cross reference for Case numbers, "old" JEDEC "TO" numbers, and the new JEDEC "TO" designation.

An information on Tape and Reel packaging capabilities is also given.

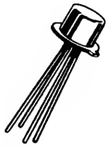
Package Outline Dimensions

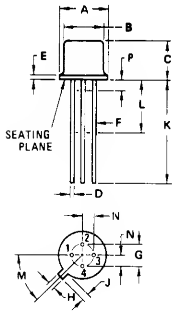
8

Package Outline Dimensions

Dimensions are in inches unless otherwise noted.

CASE 20-03 TO-72 (TO-206AF)

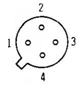




DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20 STYLES



STYLE 1
PIN 1 SOURCE
2 DRAIN
3 GATE
4 CASE LEAD

STYLE 2
PIN 1 SOURCE
2 GATE
3 DRAIN
4 SUBSTRATE AND CASE LEAD

STYLE 3
PIN 1 DRAIN
2 SOURCE
3 GATE
4 CASE LEAD

STYLE 4
PIN 1 SOURCE
2. GATE
3 DRAIN
4 GATE 2 – SUBSTRATE AND CASE

STYLE 5
PIN 1 SOURCE
2 GATE 1
3 DRAIN
4 CASE

STYLE 6
PIN 1 DRAIN
2 SOURCE AND SUBSTRATE
3 GATE
4 SOURCE AND SUBSTRATE

STYLE 7
PIN 1 DRAIN
2 SOURCE
3 GATE
4 CASE AND SUBSTRATE

STYLE 8
PIN 1 EMITTER 2
2 BASE 1
3 COLLECTOR
4 EMITTER 1 BASE 2

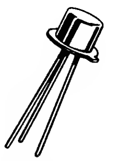
STYLE 9
PIN 1 DRAIN
2 GATE 2
3 GATE 1
4 SOURCE, SUBSTRATE AND CASE

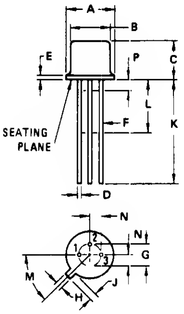
STYLE 10
PIN 1 EMITTER
2 BASE
3 COLLECTOR
4 CASE

STYLE 11
PIN 1 EMITTER
2 CATHODE
3 COLLECTOR
4 ANODE

NOTE
1 ALL RULES AND NOTES WITH TO-72 OUTLINE SHALL APPLY

CASE 22-03 TO-18 (TO-206AA)

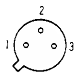




DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22 STYLES



STYLE 1
PIN 1 EMITTER
2 BASE
3 COLLECTOR

STYLE 2
PIN 1 SOURCE,SUBSTRATE AND CASE
2 GATE
3 DRAIN

STYLE 3
PIN 1 SOURCE
2 DRAIN
3 GATE

STYLE 4
PIN 1 SOURCE
2 DRAIN
3 GATE & CASE

STYLE 5
PIN 1 EMITTER
2 BASE 1
3 BASE 2

STYLE 6
PIN 1 CATHODE
2 GATE
3 ANODE

STYLE 7
PIN 1 ANODE
2 BASE
3 CATHODE

STYLE 8
PIN 1 GATE
2 ANODE 1
3 ANODE 2

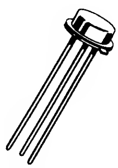
STYLE 9
PIN 1 ANODE 2
2 ANODE 1
3 GATE (CONNECTED TO CASE)

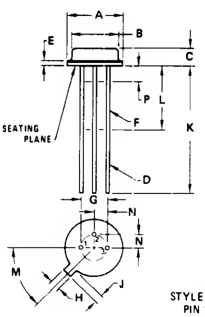
STYLE 10
PIN 1 BASE
2 EMITTER
3 BASE

STYLE 11
PIN 1 DRAIN
2 GATE
3 SOURCE, SUBSTRATE

STYLE 12:
PIN 1. SOURCE
2. GATE
3. DRAIN (CASE)

CASE 26-03 TO-46 (TO-206AB)



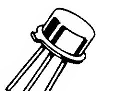


STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 27-02 TO-52 (TO-206AC)

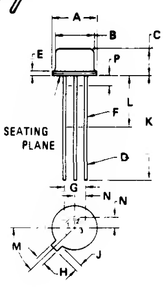


STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. DRAIN
2. SOURCE
3 GATE & CASE

STYLE 3
PIN 1. EMITTER
2. BASE
3. BASE 2

STYLE 4
PIN 1. SOURCE
2 DRAIN
3 GATE & CASE

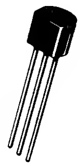


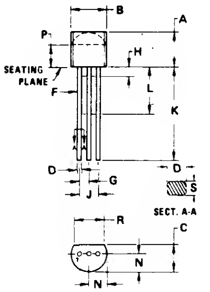
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	2.92	3.81	0.115	0.150
D	–	0.533	–	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

PACKAGE OUTLINE DIMENSIONS (continued)

CASE 29-02 TO-92 (TO-226AA)

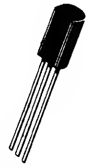


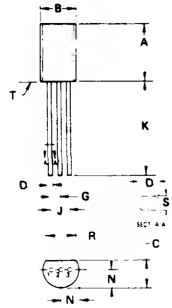


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.32	5.33	0.170	0.210
B	4.44	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.41	0.56	0.016	0.022
F	0.41	0.48	0.016	0.019
G	1.14	1.40	0.045	0.055
H	–	2.54	–	0.100
J	2.41	2.67	0.095	0.105
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.67	0.080	0.105
P	2.92	–	0.115	–
R	3.43	–	0.135	–
S	0.36	0.41	0.014	0.016

All JEDEC dimensions and notes apply.

CASE 29-03 TO-226AE





NOTES:
1. DIMENSIONS -A- AND -B- ARE DATUMS.
2. -T- IS SEATING PLANE.
3. POSITIONAL TOLERANCE FOR LEADS:
   ⌖ | Ø 0.10 (0.004) Ⓜ | T | A Ⓜ | B Ⓜ
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.37	7.87	0.290	0.310
B	4.44	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.46	0.61	0.018	0.024
G	1.27 BSC		0.050 BSC	
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
N	2.03	2.92	0.080	0.115
R	3.43	–	0.135	–
S	0.46	0.61	0.018	0.024

CASE 29 STYLES

STYLE 1
PIN 1 EMITTER
2 BASE
3 COLLECTOR

STYLE 2
PIN 1 BASE
2 EMITTER
3 COLLECTOR

STYLE 3
PIN 1 ANODE
2 ANODE
3 CATHODE

STYLE 4
PIN 1 CATHODE
2 CATHODE
3 ANODE

STYLE 5
PIN 1 DRAIN
2 SOURCE
3 GATE

STYLE 6
PIN 1 GATE
2 SOURCE & SUBSTRATE
3 DRAIN

STYLE 7
PIN 1 SOURCE
2 DRAIN
3 GATE

STYLE 8
PIN 1 DRAIN
2 GATE
3 SOURCE & SUBSTRATE

STYLE 9
PIN 1 BASE 1
2 EMITTER
3 BASE 2

STYLE 10
PIN 1 CATHODE
2 GATE
3 ANODE

STYLE 11
PIN 1 ANODE
2 CATHODE & ANODE
3 CATHODE

STYLE 12
PIN 1 MAIN TERMINAL 1
2 GATE
3 MAIN TERMINAL 2

STYLE 13
PIN 1 ANODE 1
2 GATE
3 CATHODE 2

STYLE 14
PIN 1 EMITTER
2 COLLECTOR
3 BASE

STYLE 15
PIN 1 ANODE 1
2 CATHODE
3 ANODE 2

STYLE 16
PIN 1 ANODE
2 GATE
3 CATHODE

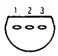
STYLE 17
PIN 1 COLLECTOR
2 BASE
3 EMITTER

STYLE 18
PIN 1 ANODE
2 CATHODE
3 NOT CONNECTED

STYLE 19
PIN 1 GATE
2 ANODE
3 CATHODE

STYLE 20
PIN 1 NOT CONNECTED
2 CATHODE
3 ANODE

STYLE 21
PIN 1 COLLECTOR
2 EMITTER
3 BASE



STYLE 22
PIN 1 SOURCE
2 GATE
3 DRAIN

STYLE 23
PIN 1 GATE
2 SOURCE
3 DRAIN

STYLE 24
1 EMITTER
2 COLLECTOR ANODE
3 CATHODE

STYLE 25
1 MT 1
2 GATE
3 MT 2

STYLE 26
PIN 1 V_{CC}
2 GROUND 2
3 OUTPUT

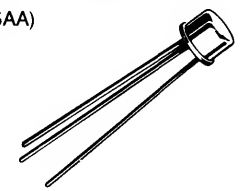
STYLE 27
PIN 1 MT
2 SUBSTRATE
3 MT

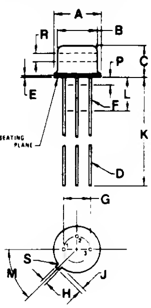
STYLE 28
PIN 1 CATHODE
2 ANODE
3 GATE

STYLE 29
PIN 1 NOT CONNECTED
2 ANODE
3 CATHODE

STYLE 30
PIN 1 DRAIN
2 GATE
3 SOURCE

CASE 31-03 TO-5 (TO-205AA)





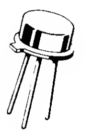
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

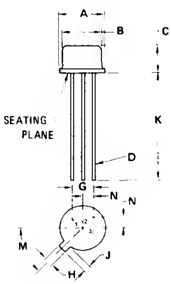
STYLE 2
PIN 1. CATHODE
2 GATE
3 ANODE

STYLE 3
PIN 1. GATE
2. CATHODE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	44.45	1.500	1.750
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	—		—	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.25	–	0.010

CASE 31A-01





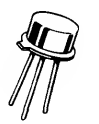
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

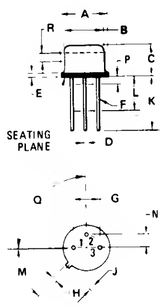
STYLE 2
PIN 1. INPUT
2. OUTPUT
3. GROUND

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.57	0.150	0.180
D	0.41	0.48	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

NOTE:
1. LEADS WITHIN 0.36 mm (0.014) DIA OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.

CASE 79-02 TO-39 (TO-205AD)





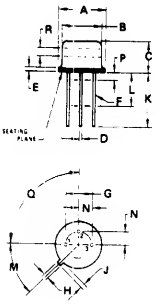
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

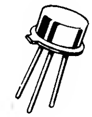
All JEDEC dimensions and notes apply

8

PACKAGE OUTLINE DIMENSIONS (continued)

CASE 79-03

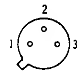




DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.02	9 30	0 355	0.366
B	8.00	8.51	0 315	0 335
C	4 19	4.57	0 165	0 180
D	0.43	0 53	0.017	0.021
E	0 43	0.89	0.017	0.035
F	0 41	0 48	0.016	0.019
G	4.83	5 33	0 190	0 210
H	0 71	0.86	0.028	0.034
J	0.74	1 02	0.029	0.040
K	12 70	–	0.500	–
M	45° NOM		45° NOM	
N	2 54 TYP		0.100 TYP	
Q	90° NOM		90° NOM	

CASE 79 STYLES

PIN 1. INPUT
2. OUTPUT
3. GROUND



STYLE 1
PIN 1 EMITTER
2 BASE
3 COLLECTOR

STYLE 2
PIN 1 DRAIN
2 SOURCE
3 GATE

STYLE 3
PIN 1 CATHODE
2. GATE
3 ANODE

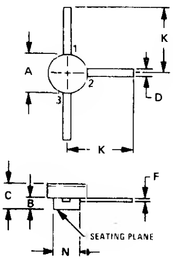
STYLE 4
PIN 1 MAIN TERM 1
2 GATE
3 MAIN TERM 2

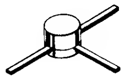
STYLE 5
PIN 1 COLLECTOR
2 BASE
3 EMITTER

STYLE 6:
PIN 1. SOURCE
2. GATE
3. DRAIN
(CASE)

NOTES
1. ALL RULES AND NOTES ASSOCIATED WITH TO-39 OUTLINE SHALL APPLY

CASE 176-02

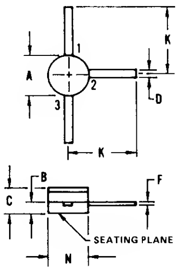


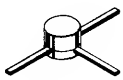


NOTE
A Tolerance of 25 mm (.010) must be allowed at point leads protrude from package for glass run over

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2 03	2.67	0.080	0.105
B	0 38	0.76	0.015	0 030
C	1.27	2 03	0.050	0 080
D	0.25	0.41	0.010	0.016
F	0.08	0 15	0.003	0 006
K	4.06	4 57	0.160	0 180
N	1 47	1 78	0.058	0 070

CASE 176B-01





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.03	2.67	0.080	0.105
B	0.38	0.76	0.015	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.015	0.003	0.006
K	4.06	4.57	0.160	0.180
N	2.03	2 67	0.080	0.105

CASE 176 STYLES

STYLE 1
PIN 1 BASE
2 EMITTER
3 COLLECTOR

STYLE 2
PIN 1 SOURCE
2 GATE
3 DRAIN

STYLE 3
PIN 1. DRAIN
2 SOURCE
3. GATE

STYLE 4
PIN 1. ANODE 2
2 ANODE 1
3. CATHODE

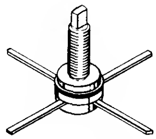
STYLE 5
PIN 1. CATHODE
2. NOT CONNECTED
3. ANODE

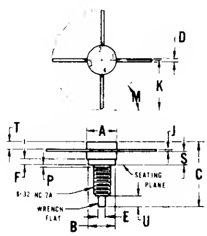
STYLE 6
PIN 1 CATHODE
2 ANODE
3 ANODE

STYLE 7
PIN 1 EMITTER
2 BASE
3 COLLECTOR

STYLE 8
PIN 1 ANODE
2. NC
3. CATHODE

CASE 244A-01





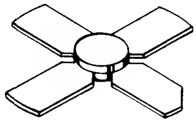
STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

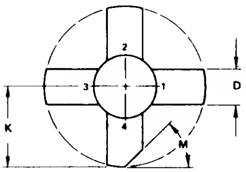
STYLE 2:
PIN 1. COMMON
2. OUTPUT
3. COMMON
4. INPUT

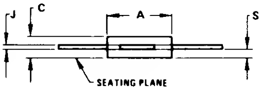
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
B	6.20	6.50	0.244	0.256
C	15.24	16.51	0.600	0.650
D	0.66	0.86	0.026	0.034
E	1.40	1.65	0.055	0.065
F	1.52	–	0.060	–
J	0.10	0.15	0.004	0.006
K	11.17	–	0.440	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
S	2.74	3.35	0.108	0.132
T	1.40	1.78	0.055	0.070
U	2.92	3.68	0.115	0.145

PACKAGE OUTLINE DIMENSIONS (continued)

CASE 249-05







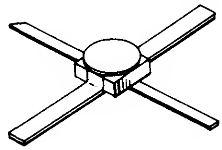
STYLE 1
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

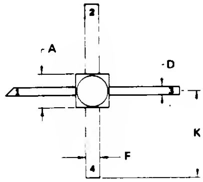
STYLE 2
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

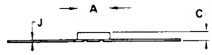
SEATING PLANE = GROUND AND IS CONNECTED TO PIN 1 AND PIN 3

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
C	2.84	3.45	0.112	0.136
D	5.46	5.97	0.215	0.235
J	0.08	0.18	0.003	0.007
K	11.05	–	0.435	–
M	45° NOM		45° NOM	
S	1.40	1.65	0.055	0.065

CASE 303-01







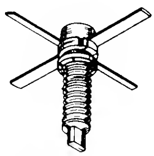
STYLE 1
PIN 1. COLLECTOR
2. EMITTER
3. BASE
4. EMITTER

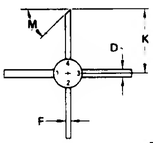
STYLE 2
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. BASE

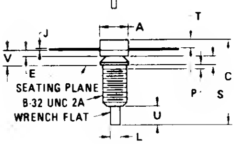
NOTE
1. DIMENSION K APPLIES TO ALL LEADS

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	2.29	2.67	0.090	0.105
C	0.89	1.40	0.035	0.055
D	0.41	0.61	0.016	0.024
F	0.89	1.09	0.035	0.043
J	0.08	0.15	0.003	0.006
K	4.45	5.84	0.175	0.230

CASE 305-01



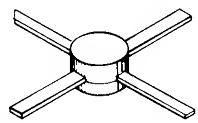


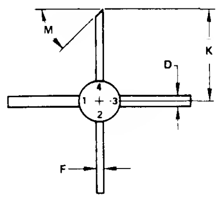


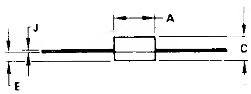
STYLE 1
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	5.08	5.59	0.200	0.220
C	13.97	16.26	0.550	0.640
D	1.40	1.65	0.055	0.065
E	1.02	1.27	0.040	0.050
F	0.64	0.89	0.025	0.035
J	0.08	0.18	0.003	0.007
K	11.05	–	0.435	–
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
S	1.40	1.65	0.055	0.065
T	1.40	1.78	0.055	0.070
U	2.79	3.81	0.110	0.150
V	2.41	2.92	0.095	0.115

CASE 305A-01



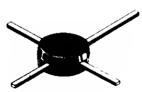


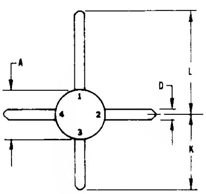


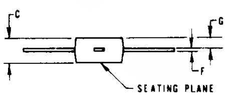
STYLE 1.
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	5.08	5.59	0.200	0.220
C	2.41	3.30	0.095	0.130
D	1.40	1.65	0.055	0.065
E	1.02	1.27	0.040	0.050
F	0.64	0.89	0.025	0.035
J	0.08	0.18	0.003	0.007
K	11.05	–	0.435	–
M	45° NOM		45° NOM	

CASE 317-01





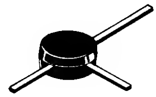


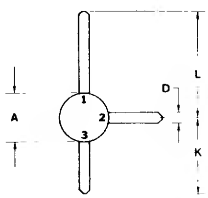
STYLE 1.
PIN 1. DRAIN
2. SOURCE
3. GATE 1
4. GATE 2

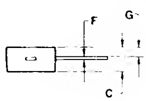
STYLE 2.
PIN 1. COLLECTOR
2. EMITTER
3. BASE
4. EMITTER

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.44	5.21	0.175	0.205
C	1.90	2.54	0.075	0.100
D	0.84	0.99	0.033	0.039
F	0.20	0.30	0.008	0.012
G	0.76	1.14	0.030	0.045
K	7.24	8.13	0.285	0.320
L	10.54	11.43	0.415	0.450

CASE 317A-01







STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER

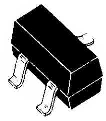
STYLE 2
PIN 1. COLLECTOR
2. EMITTER
3. BASE

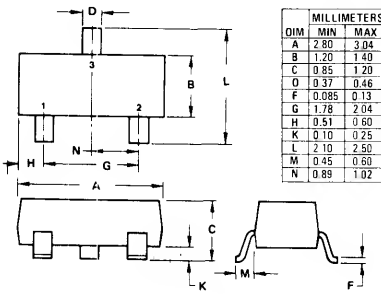
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.44	5.21	0.175	0.205
C	1.90	2.54	0.075	0.100
D	0.94	0.99	0.033	0.039
F	0.20	0.30	0.008	0.012
G	0.76	1.14	0.030	0.045
K	7.24	8.13	0.285	0.320
L	10.54	11.43	0.415	0.450

8

PACKAGE OUTLINE DIMENSIONS (continued)

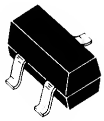
CASE 318 TO-236AA

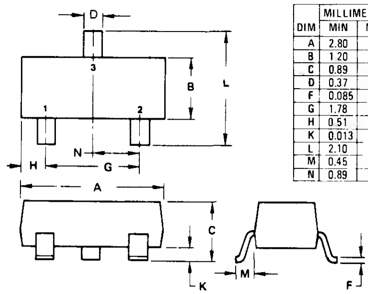




OIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2 80	3.04	0 1102	0.1197
B	1.20	1 40	0 0472	0 0551
C	0 85	1 20	0.033	0.0472
O	0 37	0.46	0 015	0.0177
F	0.085	0.13	0.0034	0.0051
G	1.78	2 04	0.0701	0.0807
H	0.51	0 60	0.020	0.0236
K	0 10	0 25	0.004	0.0098
L	2 10	2.50	0.083	0 0984
M	0.45	0.60	0.018	0.0236
N	0.89	1.02	0.035	0.0401

CASE 318 TO-236AB (Low Profile)





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.80	3.04	0 1102	0 1197
B	1 20	1 40	0.0472	0.0551
C	0.89	1.04	0.035	0.0412
D	0.37	0.46	0.015	0.0177
F	0.085	0.13	0.0034	0.0051
G	1.78	2.04	0.0701	0.0807
H	0.51	0.60	0.020	0.0236
K	0.013	0.10	0.0005	0.0040
L	2.10	2 50	0.083	0.0984
M	0.45	0.60	0.018	0.0236
N	0.89	1.02	0.035	0.0401

CASE 318 STYLES

STYLE 6
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 7
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 8
PIN 1. ANODE
2. NO CONNECTION
3. CATHODE

STYLE 9
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 10:
PIN 1. ORAIN
2. SOURCE
3. GATE

STYLE 11:
PIN 1. ANODE
2. CATHODE
3. CATHODE
ANODE

STYLE 12:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 13
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 14
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 15:
PIN 1. GATE
2. CATHODE
3. ANODE

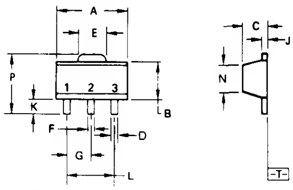
STYLE 16
PIN 1. ANODE
2. CATHODE
3. CATHODE

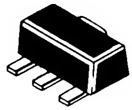
STYLE 17
PIN 1. NO CONNECTION
2. ANODE
3. CATHODE

STYLES 1 THRU 5 ARE OBSOLETE.

NOTES
1. 318-02 MEETS ALL JEOEC DIMENSIONAL REOUIREMENTS FOR TO-236 AA.

CASE 345-01





STYLE 1
PIN 1. BASE
2. COLLECTOR
3. EMITTER

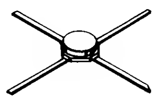
STYLE 2
PIN 1. ANODE
2. CATHODE
3. NO CONNECTION

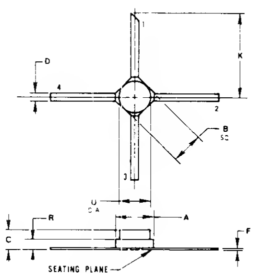
STYLE 3
PIN 1. GATE
2. ANODE
3. CATHODE

STYLE 4
PIN 1. DRAIN
2. GATE
3. SOURCE

OIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.40	4.60	0.174	0 181
B	2 29	2.60	0 091	0.102
C	1 40	1.60	0.056	0 062
D	0 36	0 48	0.015	0 018
E	1 62	1.80	0 064	0.070
F	0.44	0.53	0.018	0 020
G	1 50 BSC		0.059 BSC	
J	0 35	0.44	0.014	0.017
K	0 80	1 04	0 032	0.040
L	3.00 BSC		0.118 BSC	
N	2 04	2.28	0 081	0.089
P	3 94	4.25	0.156	0 167

CASE 358-01



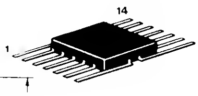


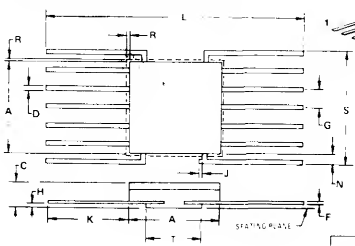
STYLE 1
PIN 1. BASE
2. EMITTER
3. COLLECTOR
4. EMITTER

STYLE 2
PIN 1. ORAIN
2. SOURCE
3. GATE 1
4. GATE 2

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.41	2.92	0.095	0 115
B	1 95	2.36	0.077	0.093
C	1.09	1 60	0.043	0.063
O	0.43	0 58	0.017	0.023
F	0.07	0.15	0.003	0.006
K	4 82	6.60	0.190	0.260
R	0.53	0.96	0.021	0.038
U	1.98	2.18	0.078	0.086

CASE 607-04 CERAMIC



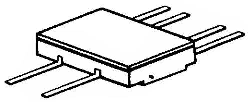


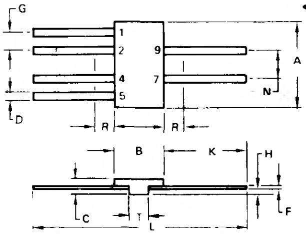
STYLE 1
BASE 2, 6, 9, 13
EMITTER 3, 5, 10, 12
COLLECTOR 1, 7, 8, 14
FOR COMPLEMENTARY OUADS
NPN PINS 1 THRU 3, 12 THRU 14
PNP PINS 5 THRU 7, 8 THRU 10
(REFER TO STYLE 1
FOR PIN IDENTIFICATION)

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6 10	6 99	0.240	0 275
C	0 76	2 03	0.030	0 070
O	0 25	0.48	0 010	0 019
F	0 08	0 15	0 003	0.006
G	1.27 BSC		0.050 BSC	
H	0 13	0 89	0 005	0 035
J	-	0 38	–	0.015
K	6 35	-	0 250	–
L	18 80	–	0 740	-
N	0 25		0.010	–
R		0 38	-	0 015
S	7 62	8 38	0 300	0 330
T	4 45	4 95	0 175	0 195

PACKAGE OUTLINE DIMENSIONS (continued)

CASE 610A-04 CERAMIC

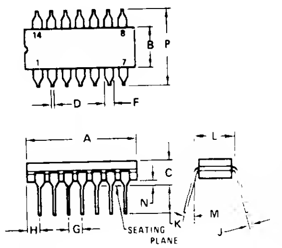


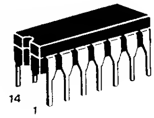


STYLE 1
BASE 1, 5
EMITTER 2, 4
COLLECTOR 9, 7
FOR COMPLEMENTARY PAIRS
NPN PINS 1, 2, 9
PNP PINS 4, 5, 7
(REFER TO STYLE 1 FOR PIN IDENTIFICATION)

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6 10	7 37	0 240	0 290
B	2 92	4 06	0 115	0 160
C	0 76	2 03	0 030	0 070
D	0 36	0 48	0 014	0 019
F	0 08	0 15	0 003	0 006
G	1 27 BSC		0.050 BSC	
H	0.13	0 89	0 005	0 035
K	3 81	-	0 150	-
L	10.54	-	0 415	-
N	2 54 BSC		0 100 BSC	
R	-	1 27	-	0 050
T	1 65	2 03	0 065	0 080

CASE 632-02 TO-116 CERAMIC





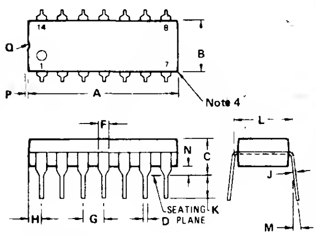
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16 8	19 9	0 660	0 785
B	5 59	7 11	0 220	0 280
C	-	5 08	-	0 200
D	0 381	0 584	0 015	0 023
F	0.77	1 77	0 030	0 070
G	2 54 BSC		0 100 BSC	
J	0 203	0 381	0 008	0 015
K	2 54		0 100	-
L	7 62 BSC		0 300 BSC	
M	-	15°	-	15°
N	0 51	0 76	0 020	0 030
P	-	8 25		0 325

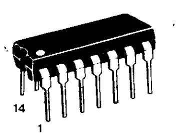
STYLE 1
COLLECTOR 1, 7, 8, 14
BASE 2, 6, 9, 13
EMITTER 3, 5, 10, 12
COMPLEMENTARY PAIRS

	TYPE 1	TYPE 2
NPN	1 THRU 3, 5 THRU 7	1 THRU 3, 12 THRU 14
PNP	8 THRU 10, 12 THRU 14	5 THRU 7, 8 THRU 10

(REFER TO STYLE 1 FOR PIN IDENTIFICATION)

CASE 646-05





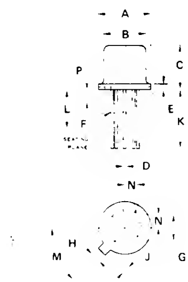
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.16	19 56	0.715	0.770
B	6.10	6 60	0.240	0 260
C	4.06	5.08	0.160	0 200
D	0.38	0.53	0.015	0.021
F	1.02	1.78	0.040	0.070
G	2 54 BSC		0 100 BSC	
H	1.32	2.41	0.052	0 095
J	0.20	0 38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	10°	0°	10°
N	0 51	1.02	0.020	0 040

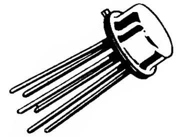
STYLE 1
BASE 2, 6, 9, 13
EMITTER 3, 5, 10, 12
COLLECTOR 1, 7, 8, 14
COMPLEMENTARY PAIRS

	TYPE 1	TYPE 2
NPN	1 THRU 3, 5 THRU 7	1 THRU 3, 12 THRU 14
PNP	8 THRU 10, 12 THRU 14	5 THRU 7, 8 THRU 10

(REFER TO STYLE 1 FOR PIN IDENTIFICATION)

CASE 654-02

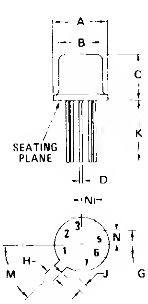


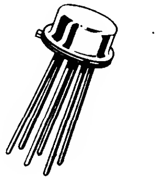


NOTES:
1. ALL RULES & NOTES ASSOCIATED WITH REFERENCED TO-78 (654-02) OUTLINE SHALL APPLY

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9 40	0.335	0 370
B	7.75	8 51	0.305	0.335
C	4.19	4.70	0.165	0.185
D	0 41	0.53	0.016	0.021
E	–	1.02	–	0.040
F	0.41	0.48	0 016	0.019
G	5.08 BSC		0 200 BSC	
H	0 71	0.86	0.028	0.034
J	0 74	1.14	0.029	0.045
K	12.70	–	0.500	–
L	6.35	–	0 250	–
M	45° BSC		45° BSC	
N	2.54		0.100 BSC	
P	–	1.27	–	0.050

CASE 654-07





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8 51	9 40	0 335	0 370
B	7 75	8 51	0.305	0 335
C	3 81	4 70	0 150	0 185
D	0 41	0 53	0 016	0 021
G	5 08 BSC		0 200 BSC	
H	0.71	0 86	0 028	0 034
J	0 74	1 14	0 029	0 045
K	12 70		0 500	
M	45° BSC		45° BSC	
N	2 54 BSC		0 100 BSC	

CASE 654 STYLES

STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

STYLE 2:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. SOURCE
6. DRAIN
7. GATE
8. OMITTED

STYLE 3:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. OMITTED
5. ANODE
6. NO CONNECTION
7. CATHODE
8. OMITTED

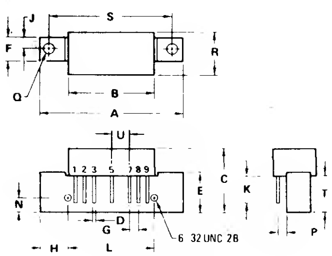
STYLE 4
PIN 1. GATE
2. SOURCE
3. DRAIN
4. OMITTED
5. DRAIN
6. SOURCE
7. GATE
8. OMITTED

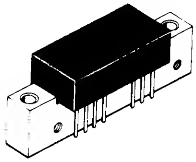
STYLE 5
SIDE 1 (NPN)
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
SIDE 2 (PNP)
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

STYLE 6
PIN 1. SOURCE
2. DRAIN
3. GATE
4. OMITTED
5. SOURCE
6. DRAIN
7. GATE
8. OMITTED

PACKAGE OUTLINE DIMENSIONS (continued)

CASE 714-02





FIRST STAGE PIN 1, RF IN
4, RF OUT

SECOND STAGE PIN 6, RF IN
9, RF OUT

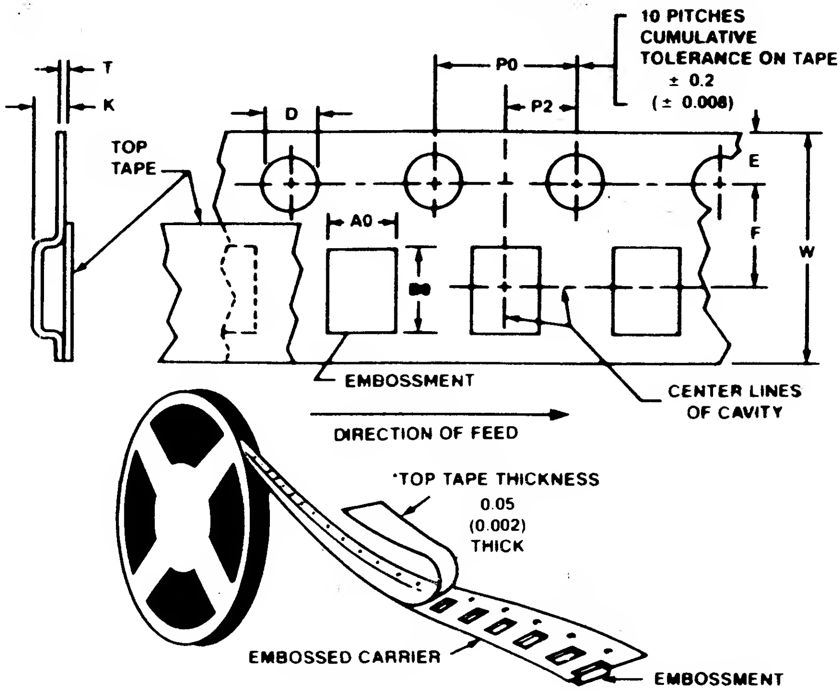
Vdc PIN 5

DC AND RF GROUND PINS 2, 3, 7, 8

NOTE
1 MOUNTING HOLES WITHIN 0.25 mm (0.010) DIA OF TRUE POSITION AT MAXIMUM MATERIAL CONDITION

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	-	45.08		1.775
B	26.42	26.92	1.040	1.060
C	20.57	21.34	0.810	0.840
D	0.46	0.56	0.018	0.022
E	11.81	12.95	0.465	0.510
F	7.62	8.13	0.300	0.320
G	2.41	2.67	0.095	0.105
H	9.65	9.78	0.380	0.385
J	3.96 BSC		0.156 BSC	
K	6.86	7.37	0.270	0.290
L	25.40 BSC		1.000 BSC	
N	4.06	4.32	0.160	0.170
P	2.16	2.92	0.085	0.115
Q	3.76	4.27	0.148	0.168
R	-	15.11	-	0.595
S	38.10 BSC		1.500 BSC	
T	11.05	11.43	0.435	0.450
U	4.95	5.21	0.195	0.205

8 mm TAPE CARRIER (EIA STANDARD RS-481) Dimensions in mm (in.)



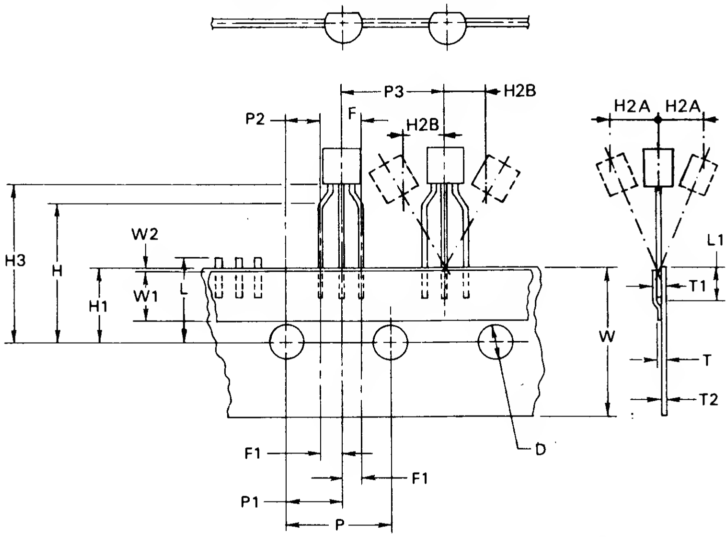
W	F	E	P2	P0	D	T	K	A0, B0
8.0 ± 0.2 (0.315 ± 0.008)	3.5 ± 0.05 (0.138 ± 0.002)	1.75 ± 0.05 (0.069 ± 0.002)	2.0 ± 0.05 (0.079 ± 0.002)	4.0 ± 0.1 (0.157 ± 0.004)	$1.5^{+0.1}_{-0.0}$ $(0.059^{+0.004}_{-0.000})$	0.3 MAX. (0.012)	2.0 MAX (0.079)	PACKAGE MAX. DIMENSIONS PLUS 0.4 ± 0.2 (0.016 ± 0.008)

8

PACKAGE OUTLINE DIMENSIONS (continued)

TO-92 RADIAL TAPE AND REEL (Dimensions in mm)

FIGURE 1 — TAPING PROCEDURE



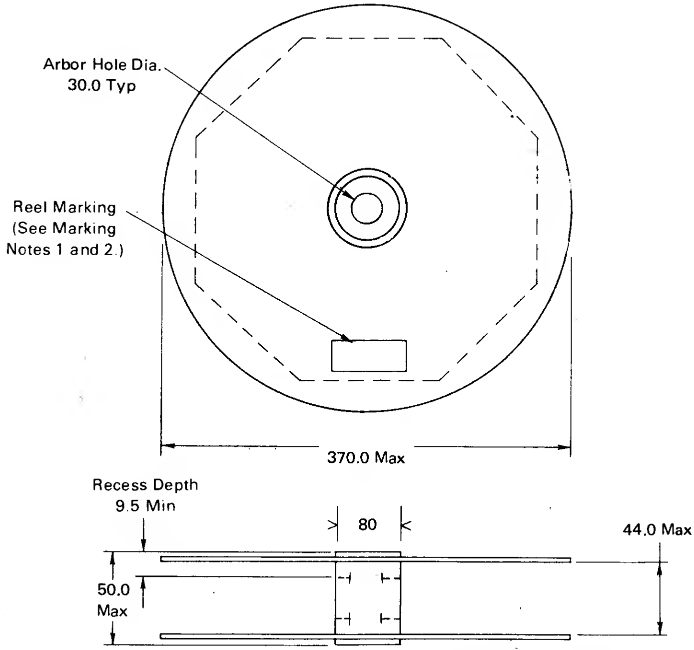
SYMBOL	ITEM	SPECIFICATION Min mm	SPECIFICATION Max mm	REMARKS
D	Tape Feed Hole Diameter	3.7	4.3	
F	Overall Component Lead Pitch	4.8	5.8	
F1	Component Lead Pitch	2.4	2.9	
H	Height of Seating Plane	15.5	16.5	Note 2
H1	Feed Hole Location	8.5	9.75	Notes 9 & 10
H2A,8	Deflection Front or Rear , Left or Right	0	1.0	Note 1
H3	Feed Hole to 8ottom of Component	18.0	19.0	
L	Lead Length After Component Removal	0	11.0	Notes 3 & 8
L1	Lead Wire Enclosure	2.5	—	Note 4
P	Feed Hole Pitch	12.4	13.0	Note 5
P1	Feed Hole — Component Center Distance	5.95	6.75	
P2	Feed Hole — First Lead Distance	3.02	4.35	
P3	Component Center Pitch	11.7	13.7	
T	Total Tape Thickness	0.5	0.9	
T1	Overall Taped Package Thickness	—	1.44	Note 6
T2	Carrier Tape Thickness	0.38	0.68	Note 6
W	Overall Tape Width	17.5	19.0	Note 7
W1	Holddown Tape Width	5.7	6.3	Note 7
W2	Holddown Tape Position	0	0.5	Note 7

NOTES:
1. Maximum alignment deviation between leads not to be greater than 0.2 mm.
2. As illustrated, the clearance to the lead standoff form shall be defined to the point of radius for the standoff form.
3. Defective components shall be clipped from the carrier tape such that the remaining protrusion (L) does not exceed a maximum of 11 mm.
4. Component lead to tape adhesion must meet the pull test requirements established in Figures 4, 5, and 6.
5. Maximum non-cumulative variation between tape feed holes shall not exceed 1.0 mm in 20 pitches.
6. Overall taped package thickness, including component leads and tape splices shall not exceed 1.44 mm.
7. Holddown tape not to extend beyond the edge(s) of carrier tape and there shall be no exposure of adhesive.
8. No more than 3 consecutive missing components is permitted.
9. A tape trailer, having at least three feed holes is required after the last component.
10. Splices shall not interfere with the sprocket feed holes.

PACKAGE OUTLINE DIMENSIONS (continued)

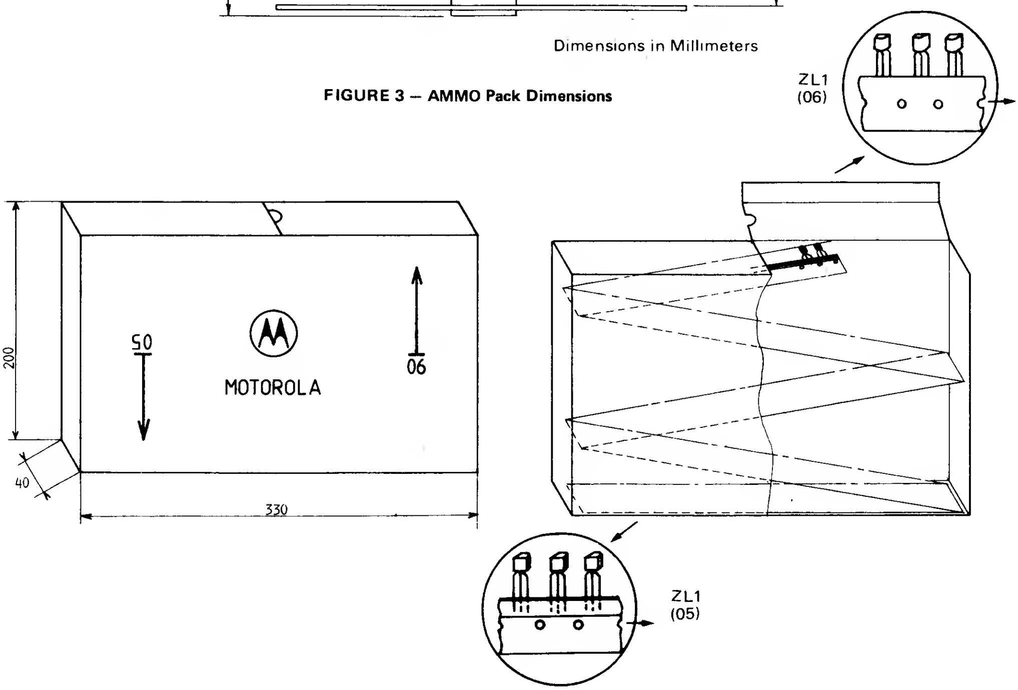
TO-92 RADIAL TAPE AND REEL

FIGURE 2 — REEL Pack Dimensions



Dimensions in Millimeters

FIGURE 3 — AMMO Pack Dimensions



TO-92 RADIAL TAPE AND REEL

FIGURE 4 – ORDERING NOTES

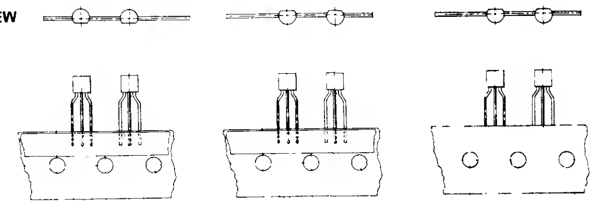
1. Each package (AMMO and REEL) contains two thousand pieces; orders have to be a multiple of 2K.
2. How to choose a style of Reel Winding ?

   It depends on the leading edge one needs to see first, on the TO92 pinning.

   See below for guidance for your specified needs.

PINNING BOTTOM VIEW		RL1/ZL1 (05)	RL	RL2/ZL1 (06)
			→ LEADING EDGE →	

TOP VIEW



TRANSISTORS

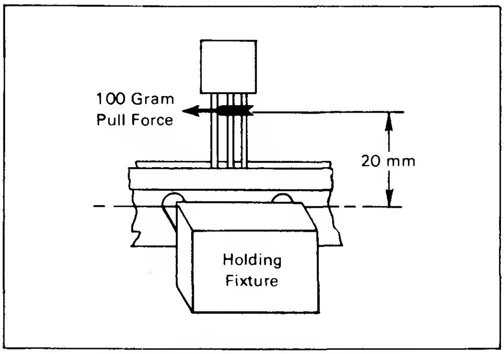
1	2	3	RL1/ZL1 (05)	RL	RL2/ZL1 (06)
			First Lead Seen	First Lead Seen	First Lead Seen
E	B	C	Collector	Emitter	Emitter
C	B	E	Emitter	Collector	Collector
B	E	C	Collector	Base	Base
E	C	B	Base	Emitter	Emitter
C	E	B	Base	Collector	Collector

FETS

1	2	3	RL1/ZL1 (05)	RL	RL2/ZL1 (06)
G	S	D	Drain	Gate	Gate
D	S	G	Gate	Drain	Drain
S	G	D	Drain	Source	Source

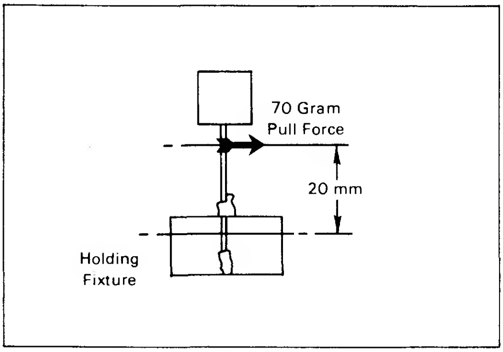
TO-92 RADIAL TAPE AND REEL

FIGURE 5 — ADHESION PULL TEST #1



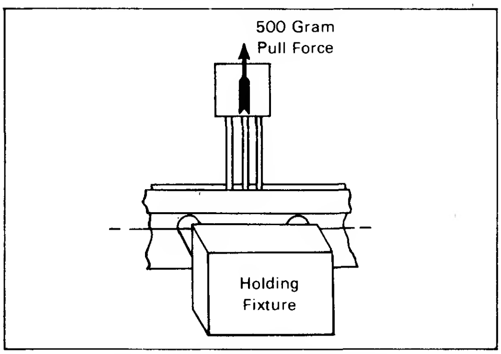
The component shall not pull free with a 100 gram load applied to the leads for 3.0 ±1 second.

FIGURE 6 — ADHESION PULL TEST #2



The component shall not pull free with a 70 gram load applied to the leads for 3.0 ±1 second.

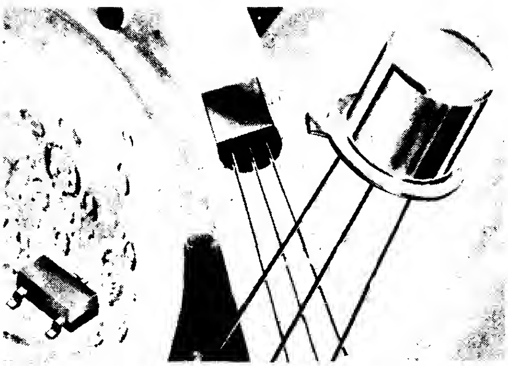
FIGURE 7 — ADHESION PULL TEST #3



There shall be no deviation in the leads and no component leads shall be pulled free of the tape with a 500 gram load applied to the component body for 3.0 ±1 second.

MARKING NOTES:

1. Minimum container and reel marking shall consist of the following items:
   a. Motorola
   b. Customer Purchase Order Number
   c. Quantity
   d. Date of Reeling
   e. Motorola Part Number
2. Where applicable, the following items will be included:
   a. Customer Part Number
   b. Device Date Code



Small-Signal Discrete products are available from Motorola in four quality and reliability classes: Industrial/ Commercial grade, High Reliability Military grade, High Reliability Space grade, and Customer Specials.

This Reliability and Quality Assurance section contains information on final test and quality assurance processing. Included is a listing of Q.A. test and the applicable CECC methods relating to the above noted quality and screening levels.

A comparison table between US MIL-STD qualified product levels (JAN, JANTX, JANTXV, JANS) and CECC assessment and screening levels is given.

A glossary of Reliability and Quality terms is also included.

Reliability and Quality Assurance

9

Reliability and Quality Assurance

Quality Levels

Most Small-Signal Discrete products are available from Motorola in four quality and reliability levels:

1. INDUSTRIAL/COMMERCIAL GRADE — Identified by a part number prefix such as 2N, BC, MM, or MPS and tested to a published Motorola, Pro-Electron or JEDEC specification.
2. Assessed Quality and Reliability products qualified or processed per CECC 50 000 according levels and classes as follow:
   CECC F — Controlled lot with sample environmental and life testing
   CECC F — with screening class B: Same as CECC F plus 100% processing
   CECC F — with screening class A: Same as CECC F plus 100% processing and 100% internal visual inspection.
3. Products for Space Level Usage qualified or processed per E.S.A./SCC specifications.
4. CUSTOMER SPECIAL — Screening, testing and marking as determined by the customer to meet his particular requirement. This may range from a custom-marked industrial/commercial grade product to a Hi-Rel product which is subjected to a series of stringent inspections and tests to meet aerospace or special military requirements.

Final Test Processing

Device lots are subjected to 100% processing in Final Test. This processing may be as simple as electrical testing to data sheet specifications or as complex as a series of mechanical, environmental and burn-in screening tests preceded and followed by electrical readouts. All lots, whether industrial/commercial, assessed quality or Hi-Rel space, are subjected to a minimum 24-hours storage bake at 150° C or 200° C.

Quality Assurance Processing

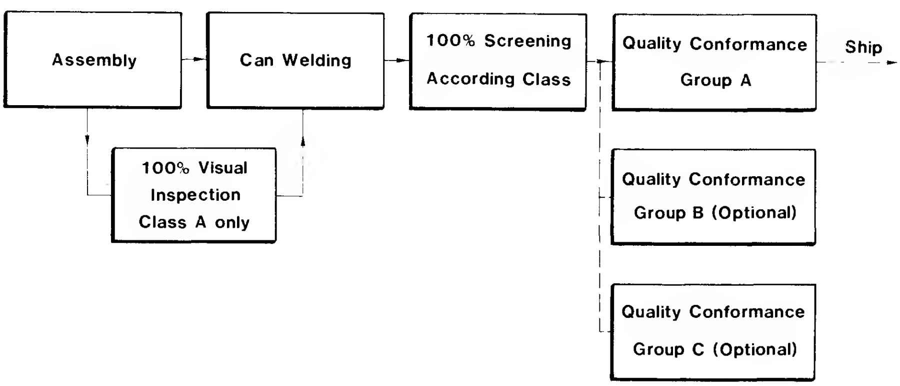
All products are transferred to QA where they are subjected to Group A electrical testing, to the customer's specification, usually the same as the one used by final test.

QA is presently performing sample testing. However, Motorola quality improvement program is planning that all Small-Signal Transistors will be subjected to 100% QA electrical testing.

High Reliability Processing of Transistors

In Europe Motorola has qualified to CECC standard the most popular Small Signal Transistors, and new types are added as market demands.

MIL-STD-750 OR CECC 50 000 PROCESSING FLOW CHART



Devices not yet qualified to CECC which must be supplied to a qualified standard can be supplied in most cases as qualified to MIL-STD-19 500 (JAN, JANTX, JANTXV or JANS). However, this solution is non preferred in Europe because these products are non standard, being imported from US factories.

Motorola Europe recommends therefore whenever possible to use parts processed in Europe.

Two programs are proposed. One is based on US MIL-STD-750 test methods and offer two classes of screening levels, "A" which is similar to JANTXV level and screening level "B" which is similar to JANTX level of MIL-STD-19 500.

The other Hi-Rel screening program is per CECC 50 000 appendix 6. Motorola offers as standard the levels A and B. Levels C and D can be obtained on special request.

Both standards MIL and CECC are similar in their philosophy and implementation. Both do guarantee on a lot by lot basis and eventually on 100% screening the reliability, the hermeticity and the solderability of transistors with comparable defect limits.

In figure 1, a flow chart of the main processing steps in both systems is described.

Figure 2 gives the comparison between Hi-Rel screening classes and assessment levels in both standards.

Figure 3 and 4 show the details of the various group A screening steps in each standard and for each class.

The list of today's Small-Signal Transistors qualified to CECC 50 000 is presented in section 1.

For more information concerning Motorola's High-Reliability capability consult the latest edition of the Hi-Rel brochure.

TABLE 1 — HIGH RELIABILITY SCREENING LEVELS FOR DISCRETE PRODUCTS

QUALIFIED (1)		PROCESSED (2)		
US Source Mandatory	European Source Mandatory	Europe		US
MIL-M-19500 to MIL-STD-750	CECC 50000	CECC 50000	MIL-STD-750	
JAN	CECC 50000 E, F	—	—	Does not exist
JANTX	CECC 50000 E, F + Screening Level B	Class B	Class B	Does not exist
JANTXV	CECC 50000 E, F + Screening Level A	Class A	Class A	Does not exist
JANS	SCC 5000 Level B	—	—	Does not exist

(1) Applicable only to qualified products with existing slash (detail) specifications. Gov. source inspection required for all qualified products.

(2) Applicable for all specifications either industry standard or MOTOROLA data sheets. No gov. source inspection mandatory but possible on request as well as customer source inspection.

TABLE 2 — PROCESSED ACCORDING TO CECC 50000

Test No.	Screen	CECC 50000 Test method	Details and conditions	Class A	Class B
1	Internal visual (precap)	Appendix VI paragraph 4		100%	—
2	High temperature stabilization bake	4.4.1	24H at max. rated storage temperature	100%	100%
3	Temperature cycling	4.4.4	5 cycles 30 min. each at min. max. storage temperature	100%	100%
4	Constant acceleration		As specified and according IEC68-2-7 and IEC147-5 (note 1)	100%	100%
5	Hermetic seal	4.410	A) fine leak: Qk or radio isotope B) gross leak: Qc	100%	100%
6 6.1 6.2	Interim electrical test By variables By attribut		 Read and record initial values Check if values are within limits of group A	 100% –	 — 100%
7	Burn-in a) Diodes b) Bipolar transistors rated at ambient temperature c) Bipolar transistors at case rated temperature d) Field effect transistors e) Rectifiers	 4.5.2.1 4.5.2.2 4.5.2.3 4.5.2.3 4.5.2.10 4.5.2.4	Duration hours Tolerances Conditions High temperature reverse bias or Power dissipation Power dissipation High temperature reverse bias High temperature reverse bias (VSB = 0, T = 150°C) Power dissipation for rectifiers rated at ambient temperature High temperature reverse bias for rectifiers rated at case temperature	168 −8	72 −4
8 8.1 8.2	Final electrical test By variable By attribute		 Per detail specification delta parameter according CECC 50000 annex VI paragraph 3 Check if values are within limit of group A	 100% —	 — 100%
	Quality conformance Group A		Per generic CECC 50000 Level F	Sampling Assessment F	Sampling Assessment F
	Typical reliability improvement compared to commercial products as per MIL HDBK 217C.			25	12

Note (1) applicable only for devices with Au wire.

TABLE 3 — PROCESSED ACCORDING TO MIL-STD-750

Test No.	Screen	MIL-STD-750 method	Condition	Level A requirements	Level B requirements
1	Internal visual (precap) inspection	2072 2074	For Transistors For Diodes	100% 100%	— —
2	High temperature stabilization bake	1032	24H at max. rated storage temperature	100%	100%
3	Temperature cycling	1051	10 cycles 15 mns each at min. max. storage temperature	100%	100%
4	Constant acceleration	2006	Y1 axis at 20000G min. or 10000G (1) for devices with PA 10W at TC = 25° C	100%	100%
5	Serialization			100%	—
6	High temperature reverse bias (HTRB)	1038 1039	For Diodes For Transistors Condition A	Option R	Option R
7	Interim electrical test		As specified By variables (read and record)	100%	—
8	Power burn-in	1038 1039 1040	For Diodes Condition B For Transistors Condition B For Thyristors Condition B	100% 160H	100% 160H
9	Final electrical test		As specified – by variables (read and – record) by attributs (GO NO GO)	100% —	— 100%
10	PDA (lot acceptance)		Applicable on electrical rejects found on pos. 9	10% max.	10% max.
11	Hermetic seal A) fine B) gross	1071	Condition G or H Condition C	100%	100%
12	Radiography	2076	See foot note (2)	100%	—
13	Electrical group A inspection (Quality conformance)		– DC parameters TA = 25° C – DC parameters at high and low temperature – Dynamic tests at TA = 25° C – AC test at TA = 25° C	AQL 0.4% Level II 0.65% Level S3 0.65% Level S3 0.65% Level S3	
14	External visual examination	2071	To be performed after complete marking	100%	100%
15	Quality conformance Group B test		See Program Options	Option Q	Option Q
	Typical reliability improvement compared to commercial products as per MIL HDBK 217C			35	18

Note (1) applicable only for devices with Au wire.
Note (2) not applicable for devices with Al wire.

9

Test Descriptions

The following tests are frequently used for screening, acceptance and evaluation of semiconductor devices.

A. Steady State Operating Life (SSOL)

The purpose of this test is to evaluate the bulk stability of the die and to generate defects resulting from manufacturing aberrations that are manifested as time and stress-dependent failures.

Conditions: T_A = 25°C, PD = max rated power

B. Intermittent Operating Life (IOL)

The purpose of this test is the same as Operating Life in addition to checking the integrity of both the wire and die bonds by means of thermal stressing.

Conditions: T_A = 25°C, PD = max rated power. $T_{(on)}$ = $T_{(off)}$ = 1 min.

C. High Temperature Storage Life

The purpose of this test is to generate time/temperature failure mechanisms and to evaluate long-term storage stability.

Conditions: T_A = 150°C no bias applied

D. High Temperature Reverse Bias (HTRB)

The purpose of this test is to align mobile ions by means of temperature and voltage stresses to form a high-current leakage path between two or more terminals.

Conditions: T_A = 150°C, V_{CB} = 80% max rated V_{CB}.

E. High Temperature High Humidity Reverse Bias (H^3TRB)

The purpose of this test is to evaluate the moisture resistance of non-hermetic components. The addition of voltage bias accelerates the corrosive effect after moisture penetration has taken place. With time, this is a catastrophically destructive test.

Conditions: T_A = 85°C, RH = 85%, V_{CB} = 80% max rated V_{CB}.

F. Moisture Resistance

The purpose of this test is to evaluate the moisture resistance of components under temperature/humidity conditions typical of tropical environments.

Conditions: Mil-Std-750, Method 1021, or
CECC 50000, Method 4.4.3

G. Pressure Cooker

The purpose of this test is to evaluate the moisture resistance of non-hermetic components under pressure/temperature conditions.

Conditions: T = 121°C, P = 1 atmosphere (15 psig)

H. Temperature Cycle (Air to Air)

The purpose of this test is to evaluate the ability of the device to withstand both exposure to extreme temperatures and the transition between temperature extremes, and to expose excessive thermal mismatch between materials.

Conditions: Mil-Std-750, Method 1051, −55°C to 150°C, 15 minutes dwell time at each temperature, or
CECC 50000, Method 4.4.4 − Na

I. Thermal Shock (Liquid to Liquid)

This test is an accelerated version of temperature cycle.

Conditions: Mil-Std-750, Method 1056, 0°C to 100°C, 15 seconds dwell time at each temperature, or
CECC 50000, Method 4.4.4 − Nc

J. Terminal Strength

The purpose of this test is to evaluate the ability of the device terminals to withstand the lead forming and tension associated with component installation into a circuit.

Conditions: Mil-Std-750, Method 2036, Condition E, or
CECC 50000, Method 4.4.9

K. Solderability

The purpose of this test is to determine the solderability of the device terminals.

Conditions: Mil-Std-750, Method 2026, or
CECC 50000, Method 4.4.7

L. Salt Atmosphere (Corrosion)

The purpose of this test is to accelerate the corrosion effects of an environment in which salt (NaC1) is present.

Conditions: Mil-Std-750, Method 1041

M. Mechanical Stress Tests

Vibration, shock and constant acceleration tests are infrequently used since they rarely generate failures in small-signal transistors. However, they are still specified for acceptance of military product.

Glossary of Reliability and Quality Terms

Acceptable Quality Level (AQL) — A measure of quality for which a given lot will be accepted most of the time. This is usually established at a probability of acceptance equal to 95%. It is referred to as the producer's risk because the probability of rejecting a good lot is 5%.

Acceptance Number (Ac) — The largest number of defectives in an inspection sample under consideration that will permit acceptance of the lot.

Acceptance Tests — Tests to determine conformance to specification requirements as a basis for lot acceptance.

Average Outgoing Quality (AOQ) — The average quality of outgoing product after 100% screening of rejected lots. This is usually measured in parts per million (PPM).

Average Outgoing Quality Limit (AOQL) — The maximum average outgoing quality that is possible for a given sampling plan.

Defect — Any deviation of a device that does not conform to specified requirements. One device may contain more than one defect.

Defective — A device which contains one or more defects.

Double Sampling — Sampling inspection in which the inspection of the first sample leads to a decision to accept, to reject, or to take a second sample. The inspection of a second sample, when required, always leads to a decision to accept or to reject.

Failure — The inability of a device to perform a specified function within previously-established limits.

Failure Rate — The statistical probability of a failure occurring within a stated period of time. For electronic components it is usually assumed that failures follow an exponential distribution, in which case the failure rate over any stated period of time is constant. The failure rate of semiconductor devices is generally given in percent per thousand hours.

Infant Mortality — Premature failures occurring at a failure rate substantially greater than that observed during subsequent life prior to wear-out.

Lot — A group of devices from which samples are drawn and inspected to determine compliance with acceptance criteria (inspection lot).

Lot Tolerance Percent Defective (LTPD) — A measure of quality for which a given lot will be rejected most of the time. This is usually established at a probability of acceptance equal to 10%. It is referred to as the consumer's risk because the probability of accepting a bad lot is 10%.

Mean Time Between Failures (MTBF) — The total measured operating time of a group of equipments divided by the total number of failures of a repairable equipment. In the case of an exponential failure distribution, this ratio is the reciprocal of failure rate.

Operating Characteristic Curve (OC curve) — A graph of the probability of acceptance as a function of the lot quality or process average quality, whichever is applicable.

Percent Defective — The number of defective devices in a lot divided by the total number of devices in that lot, multiplied by 100.

Probability of Acceptance (Pa) — The fractional probability that a lot will be accepted, usually expressed as a decimal.

Process Average Quality — The expected quality of product from a given process, usually estimated from first sample results of previous inspection lots.

Quality — A measure of the degree to which a product conforms to specification and workmanship requirements.

Rejection Number (Re) — The smallest number of defectives in an inspection sample under consideration that will prevent acceptance of the lot.

Reliability — A measure of the performance of a product over a specified period of time.

Sample — One or more devices selected at random from an inspection lot to represent that lot for acceptance purposes.

Sampling Plan — A specific plan which defines the sample size and the criteria for accepting or rejecting a lot.

Screening Tests — Tests employing nondestructive environmental, electrical, thermal and/or mechanical stresses, for the purpose of identifying anomalous devices.

Single Sampling — Sampling inspection in which a decision to accept or to reject is reached after the inspection of a single sample.

Wearout Failures — Those failures which occur as a result of deterioration processes and whose probability of occurrence increases with time.

100% Inspection — Inspection of every device, in which each device is accepted or rejected individually for the characteristic concerned, on the basis of its own inspection only.

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ELKOSE GmbH
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SASCO Vertrieb von elektronischen Bauelementen GmbH (Main Office)
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CELDIS ITALIANA S.p.A. (Main Office)
CELDIS ITALIANA S.p.A.
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CELDIS ITALIANA S.p.A.
CRAMER ITALIA S.p.A. (Main Office)
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SILVERSTAR LTD. S.p.A. (Main Office)
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